NASA CONTRACTOR REPORT 166151

Assessment of Historical and Projected Segements of U.S. and World Civil and Military Rotorcraft Markets: 1960 - 1990

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Bell Helicopter Textron

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National Aeronautics and
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PREFACE

This report reflects the work accomplished by Bell Helicopter Textron under National Aeronautics and Space Administration Contract NAS2-10404 "Assessment of Historical and Projected Segments of U.S. and World Civil and Military Rotorcraft Markets".

The project was sponsored by the Ames Research Center, Moffett Field, California. The contract was administered by Contracting Officer Ms. Carmen Young and conducted under the technical direction of Mr. William Snyder. Contract work began in October 1979 and was completed through draft report in January 1981.

Tasks performed in compiling this report were performed under the direction of BHT Project Engineer, William J. Yates, assisted by Senior Market Analyst, Earl Boyd, Market Analyst, William Klim, Engineering Specialist, Ben Scott, and Market Researcher, Susan Fox.

Special acknowledgement is given also to Management Sciences Analyst, Scott Mahan, Computer Programmer, Casey Haugland, Mag Card Typist, Lory Love, Marketing Advanced Products Specialist, John Oswalt, Market Development Specialist, John Erskine and Tech Administrator, Eloise Vaughan.

This report is a study of the history and future of helicopters, with an assessment of segments of markets, and the sensitivity to new technology as specified in the contract.

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INTRODUCTION

This study was performed under NASA Contract NAS2-10404, "A Market Study of Civil and Military Helicopters." The contract called for two tasks to be accomplished.

Task 1

- Conduct a twenty-year historical analysis and a ten-year forecast of the U.S. and free-world markets by market segments.
- Discuss key influences on market growth.
- Review strengths and weaknesses of U.S. technology.

Task 2

- Forecast the civil market sensitivity to new technology with selected premises as to vehicle life, noise standards, fuel costs, GNP expansion, air traffic growth.
- The forecast is based on a scenario of helicopter technology improvements resulting in increased size and performance.

This study used the Bell Helicopter Textron data base, which contains information from a wide variety of sources. These sources include records from the U.S. government, ICAO, foreign governments, civil aircraft registers from 45 countries, trade association publications, and the United Nations and Bell Helicopter Textron records. BHT records include field reports from marketing staff, field service representatives, and international marketing representatives.

A detailed study has been made of each of seventy-five key countries. The geographic, climatic, political, economic, and demographic environment of each country has been analyzed with respect to helicopter procurement history and usage. The overall environment is discussed in Enclosure I. Key environmental indicators which are variable have been projected into the future to serve as a base for forecasts for this study.

The forecasts, made subjectively, based upon a building-block analysis, model-by-model, mission-by-mission, country-by-country, has been compared to a forecast made by computer models. Overall, they are within 10 percent of each other.

TASK 1

An assessment of the Historical and Projected segments of U.S. and World Civil and Military Rotorcraft Markets.

The helicopter industry over the past has shown a remarkably healthy growth. This growth, for the most part, has been spurred by a series of events ranging from geopolitical actions to technical breakthroughs. However, its continued growth in size and in breadth is largely due to a relatively few highly innovative individuals and institutions willing to take high risks exploring the utilization of helicopters in untried areas.

The introduction of the gas turbine powerplant in the 1950's gave tremendous impetus to the rotorcraft market by virtue of the vast improvement in power-to-weight ratio. Military forces were the first to exploit this breakthrough. The European rotorcraft industry received its first impetus from the requirements of the French military for the Algerian War. The Vietnam war provided a major impetus to U.S. industry to meet the needs of the U.S. military forces.

A commercial organization in Louisiana took the initiative of providing helicopter support with the outset of offshore petroleum drilling operations. This has grown worldwide into an industry employing over 1000 helicopters with the highest utilization (flight hours per month) in the industry. Other innovative leaders have included a commercial helicopter operator in Colombia using helicopters for construction of a pipeline over the Andes, the Los Angeles Police Department, the Chicago Fire Department, and many others.

Procurement of helicopters increased dramatically between 1960 and 1967, increasing fivefold to more than 3500 units per year; then dropped off to less than half that rate by 1978. Since then the rate has sharply increased and is forecast to reach a level of nearly 4000 units per year by 1990.

The dollar investment in helicopters has increased even faster. In 1960 the investment was just over $200 million. Due to inflation and increasing quantities, size and complexity, by 1970 the investment was more than $1.6 billion and reached $2 billion by 1979. It is expected to grow to more than $10 billion by 1990. Thirty-three percent of this increase is due to inflation, forecast at 8 percent per year compounded.

The following sub-tasks analyze this growth supplemented by tables and graphs (figures). The dollar quantities may not total the same from table to table due to rounding. The graphs, plotted by computer, are approximate, as the computer rounded the quantities to the value of the nearest plotting line before plotting. In some cases, for low values the rounding was to zero.

Task 1.1 - Major civil and military manufacturers rotorcraft production, sales dollars, license production, and number of direct rotorcraft employees over the period 1960 through 1990.

Free World Civil Rotorcraft Production (Table/Figure 1.1 a, b)
Unit production has increased by nearly 2-1/2 times for each decade beginning with 1960. It is forecast to more than double again by 1990. Bell has dominated production from the outset and is forecast to do so through 1990. During the 1960's, Hughes was second followed by Sikorsky. During the 1970's, Aerospatiale replaced Sikorsky in third position and is forecast to replace Hughes in second position by 1990. The manufacturer titled 'other' includes all other manufacturers including licensed production of Bell, Aerospatiale, Hughes, Sikorsky, and MBB, other than that conducted by Agusta and Westland.

Civil production suffered a slight setback in 1965 as U.S. manufacturing capacity converted to military production for Vietnam. It suffered a more dramatic setback in the 1974/1977 period following the world wide impact of the OPEC increase in the price of oil. However, it has now resumed its very strong growth pattern which began at the start of the 1970's.

Free world civil rotorcraft sales in $ millions over the years has increased much faster than unit sales as would be expected with the growth of the size and complexity of helicopters, and with inflation. During the 1960's, dollar sales increased 4-1/2 times. During the 1970's, the increase was more than 12 times to a level of $850 million by 1980. By 1990 sales are forecast to increase approximately 7-1/2 times to $4.236 billion. Inflation alone (at 8%/yr.) would increase 1980 sales to $1.835 billion, leaving $2.4 billion which is a reflection of increased quantities, sizes, and complexities of helicopters.

TABLE 1.1(a). - FREE WORLD CIVIL ROTORCRAFT PRODUCTION (UNITS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
AEROSPATIALE	4	7	16	15	13	24	3	14	15	41	58
AGUSTA	10	11	12	34	23	36	9	37	63	26	44
BELL HELICOPTER	71	96	65	113	122	127	200	286	308	306	248
BOEING VERTOL	6	1	3	1	6	4	0	0	6	0	0
HUGHES	0	7	83	140	158	108	87	47	63	78	122
MBB	0	6	6	6	0	0	6	0	1	0	6
OTHER	117	199	136	113	133	96	83	97	81	56	64
SIKORSKY	20	9	27	34	23	25	19	26	35	23	11
WESTLAND	6	1	8	0	8	3	12	1	3	19	0
TOTAL CIVIL	222	331	370	450	480	423	413	508	569	549	547

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
AEROSPATIALE	58	92	58	111	93	67	67	95	104	229	333
AGUSTA	44	51	41	29	19	46	12	16	36	42	62
BELL HELICOPTER	248	229	284	414	380	400	356	311	365	547	679
BOEING VERTOL	6	6	1	0	0	0	0	0	0	0	0
HUGHES	122	123	121	178	229	203	196	200	189	283	365
MBB	0	10	22	23	36	16	21	16	24	15	40
OTHER	64	35	65	180	120	111	141	103	102	197	200
SIKORSKY	11	18	32	99	34	25	16	14	15	37	80
WESTLAND	6	6	1	0	1	0	0	0	3	0	0
TOTAL CIVIL	547	558	625	1040	914	862	803	757	838	1350	1699

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
AEROSPATIALE	353	362	370	391	408	424	445	462	479	499	516
AGUSTA	62	57	62	62	62	67	67	72	72	72	77
BELL HELICOPTER	679	728	790	881	974	1071	1170	1262	1318	1410	1505
BOEING VERTOL	0	1	3	3	4	4	4	4	4	4	4
HUGHES	365	350	360	375	385	400	416	430	440	455	465
MBB	40	30	34	39	40	50	50	50	50	50	50
OTHER	200	223	233	243	248	253	240	245	250	255	260
SIKORSKY	80	100	100	100	100	100	100	105	112	118	118
WESTLAND	0	0	0	0	0	0	0	0	0	0	0
TOTAL CIVIL	1699	1851	1952	2094	2221	2369	2486	2636	2725	2863	2995

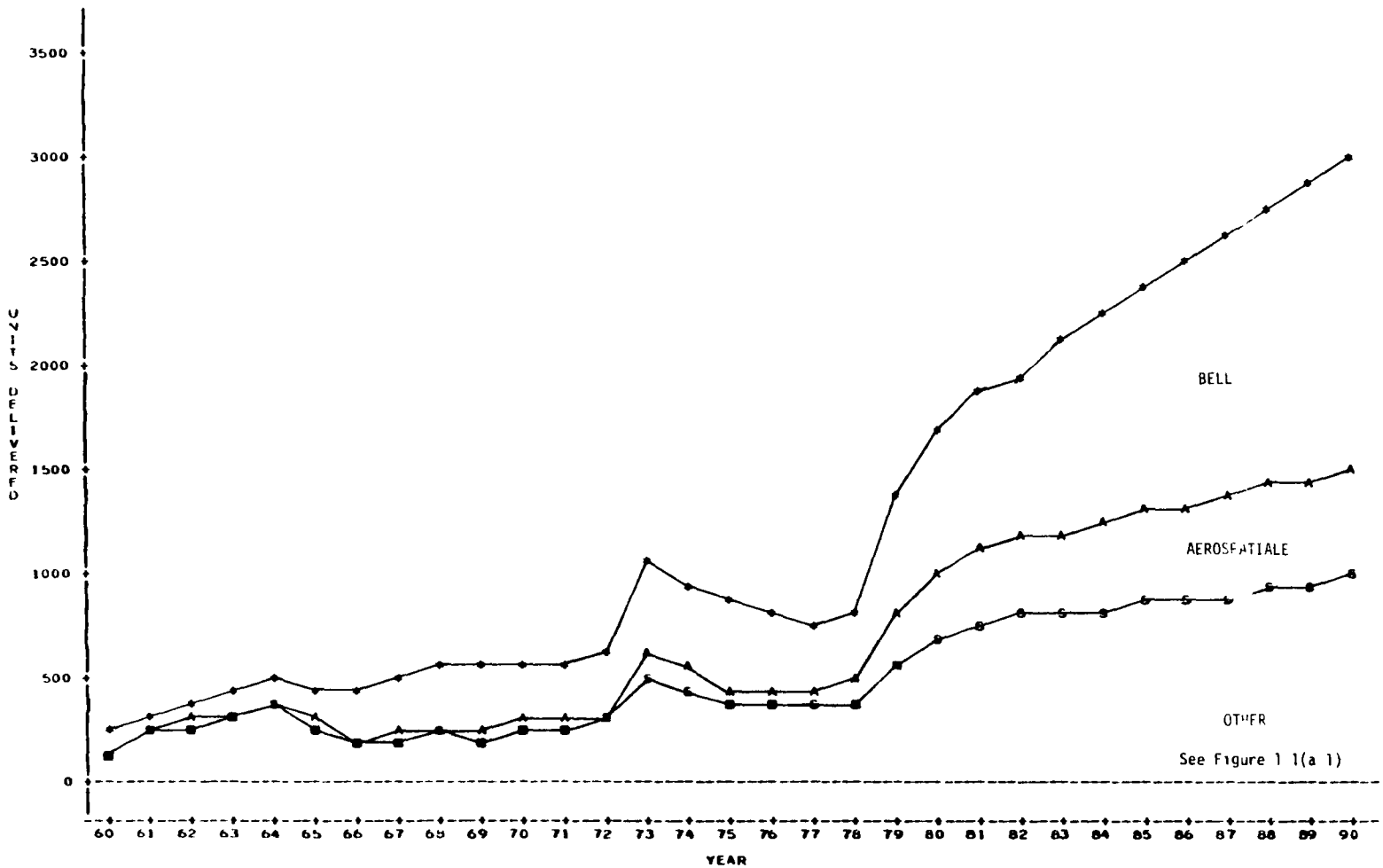

Figure 1.1(a). - Free world civil rotorcraft production (units).

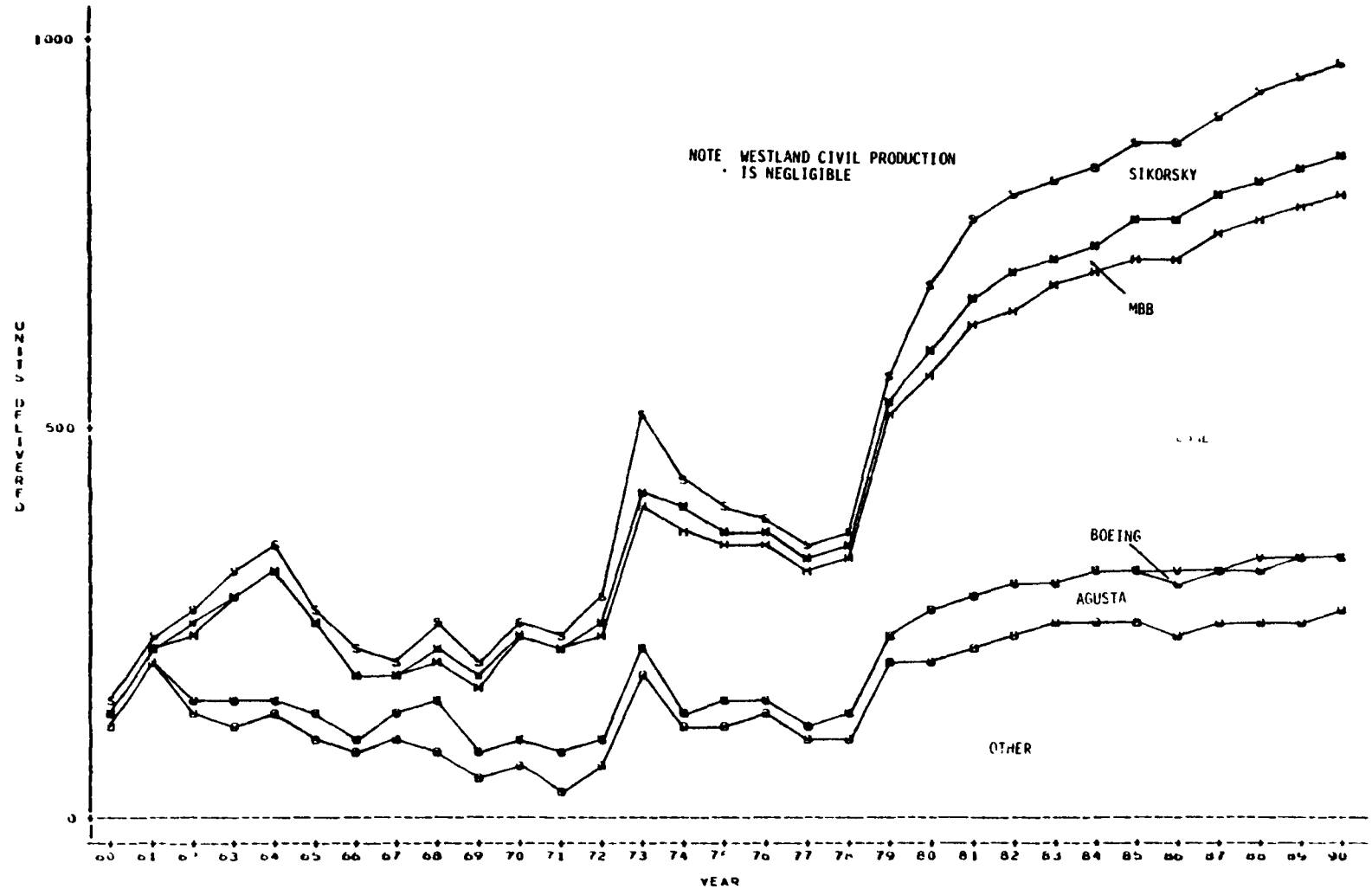

Figure 1.1(a 1). - Free world civil rotorcraft production (units).

TABLE 1.1(b). - FREE WORLD CIVIL ROTORCRAFT PRODUCTION ($ MILLIONS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
AEROSPATIALE	0	1	2	2	2	3	0	2	2	8	10
AGUSTA	1	1	0	4	3	2	1	3	6	3	5
BELL HELICOPTER	4	5	5	8	9	11	15	27	33	43	32
BOEING VERTOL	0	1	2	1	0	3	0	0	0	0	0
HUGHES	0	0	2	4	5	4	3	2	2	6	8
MBB	0	0	0	0	0	0	0	0	0	0	0
OTHER	5	9	8	6	7	8	5	9	9	8	7
SIKORSKY	5	2	9	12	8	10	7	8	24	24	5
WESTLAND	0	0	1	0	2	2	4	1	2	2	0
TOTAL CIVIL	15	19	29	36	35	40	35	53	78	92	67

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
AEROSPATIALE	10	18	18	32	39	29	29	76	88	142	154
AGUSTA	5	11	7	7	5	15	5	9	18	28	61
BELL HELICOPTER	32	33	54	84	100	125	121	107	139	219	341
BOEING VERTOL	0	0	0	0	0	0	0	0	0	0	0
HUGHES	8	10	13	18	24	24	22	29	25	54	58
MBB	0	0	0	8	14	6	9	10	18	12	35
OTHER	7	4	7	20	10	14	15	15	19	24	22
SIKORSKY	5	12	13	31	36	46	37	43	44	71	136
WESTLAND	0	0	0	0	2	0	0	0	15	0	0
TOTAL CIVIL	67	88	111	200	233	260	239	288	365	550	807

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
AEROSPATIALE	154	216	236	275	319	370	434	497	566	657	745
AGUSTA	61	80	72	77	85	100	108	127	137	148	172
BELL HELICOPTER	341	466	610	741	844	992	1170	1393	1555	1835	2166
BOEING VERTOL	0	16	32	43	64	91	96	106	114	123	133
HUGHES	56	74	83	95	106	121	135	155	173	195	217
MBB	35	28	35	43	47	63	68	74	80	86	93
OTHER	22	50	60	70	77	84	54	60	66	72	80
SIKORSKY	136	184	198	214	231	250	270	329	413	499	536
WESTLAND	0	0	0	0	0	0	0	0	0	0	0
TOTAL CIVIL	807	1076	1320	1558	1793	2071	2337	2741	3104	3615	4144

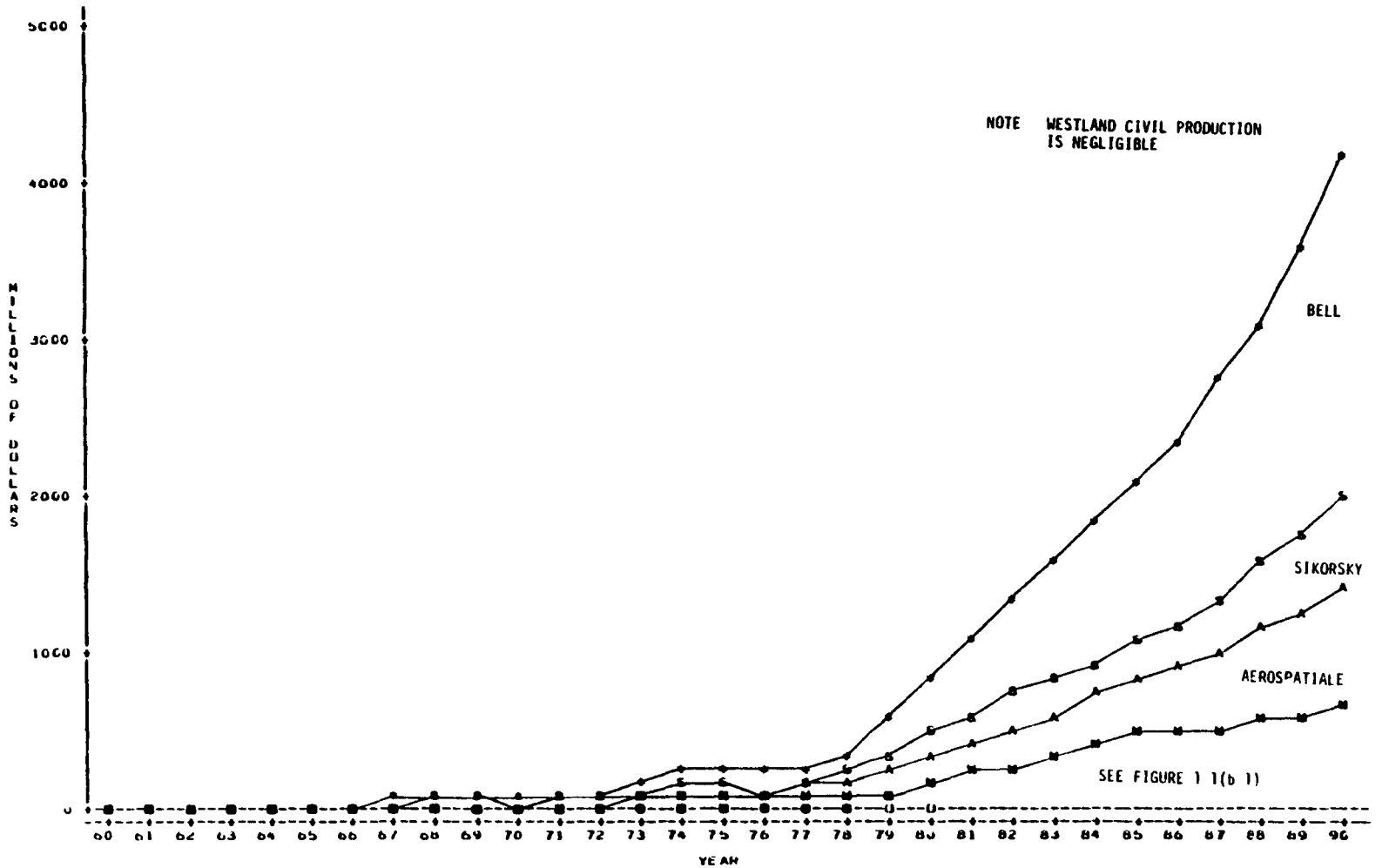

Figure 1.1(b). - Free world civil rotorcraft production ($ millions).

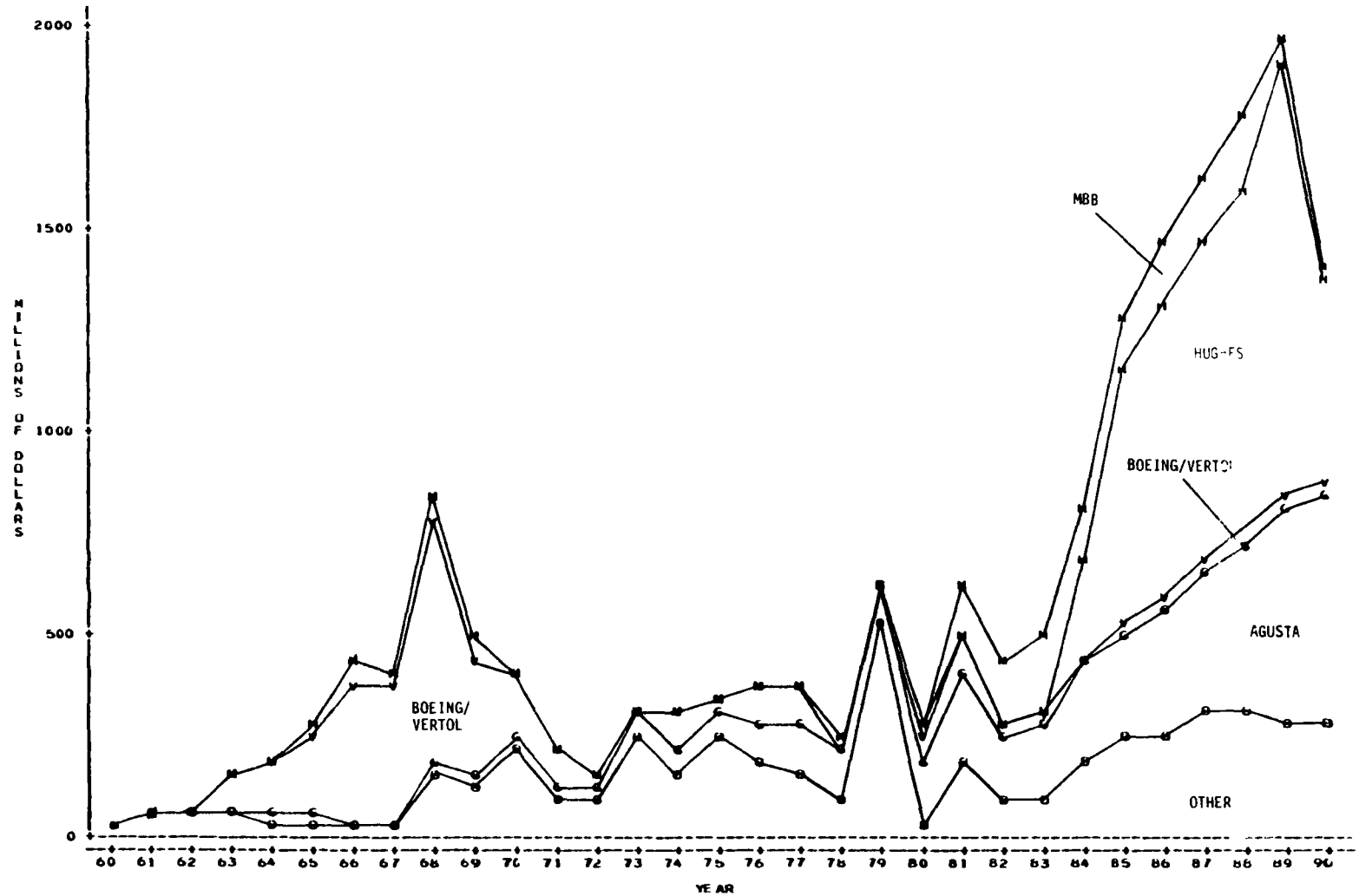

Figure 1.1(b 1). - Free world civil rotorcraft production ($ millions).

Free World Military Rotorcraft Production (Table/Figure 1.1 c & d) - Unit production for military forces was less than 1000 per year in 1960. It peaked in 1968 at more than 3000 units per year. The increase was caused largely by the creation and deployment of U.S. Army air mobile forces to Vietnam. Production stayed above 2000 units per year through 1970 as other military forces adopted the concept of air mobility. By 1980 it had dwindled to less than 700 units per year, taking a sharp decrease in 1974 after the OPEC oil price increase. Production is forecast to steadily climb throughout the 1980's as military forces modernize, upgrade, and expand to meet increasing military threats discussed in Enclosure I.

During the 1960's, Bell dominated military unit production, increasing tenfold between 1960 and 1967, then dropping sharply in 1971 with the end of the Vietnam War. Boeing/Vertol also showed a strength in the 1964/1969 period. Sikorsky decreased over both decades and Aerospatiale fluctuated with modernization cycles of French forces. For the future, Sikorsky and Hughes U.S. military orders cause strong growth, particularly in dollars because of the high cost of new weapons systems. Aerospatiale also shows strength through 1990 with new cyclic procurement planned for French forces.

TABLE 1.1(c). - FREE WORLD MILITARY ROTORCRAFT PRODUCTION (UNITS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
AEROSPATIALE	243	113	208	174	104	71	75	57	37	107	217
AGUSTA	34	25	46	63	95	72	41	68	71	100	92
BELL HELICOPTER	186	152	184	370	713	968	1557	1832	1630	1497	1601
BOEING VERTOL	0	0	10	115	99	149	253	239	293	138	75
HUGHES	0	0	15	11	147	137	392	453	638	437	70
MBB	0	0	0	0	0	0	0	0	0	0	0
OTHER	322	239	362	248	204	196	101	105	247	231	221
SIKORSKY	146	177	216	234	95	93	127	179	108	82	113
WESTLAND	39	54	106	105	101	133	186	129	73	28	23
TOTAL MILITARY	970	760	1149	1320	1558	1819	2732	3062	3097	2620	2612

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
AEROSPATIALE	217	220	76	127	127	174	184	182	152	94	72
AGUSTA	92	74	109	126	153	105	79	108	76	69	100
BELL HELICOPTER	1801	1267	1204	795	323	465	389	320	234	177	165
BOEING VERTOL	75	46	14	4	31	14	26	22	4	2	15
HUGHES	70	14	16	17	19	7	14	18	105	38	65
MBB	0	0	0	14	0	24	18	2	23	0	16
OTHER	221	113	113	206	207	198	157	129	86	138	44
SIKORSKY	113	48	23	44	49	23	10	9	13	37	99
WESTLAND	23	26	29	30	17	33	24	32	85	95	75
TOTAL MILITARY	2612	1808	1584	1363	926	1063	901	822	780	650	671

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
AEROSPATIALE	72	83	105	114	127	141	150	163	176	186	199
AGUSTA	100	105	99	104	109	109	118	118	123	128	128
BELL HELICOPTER	165	92	125	111	123	146	149	145	167	175	180
BOEING VERTOL	15	18	3	3	3	3	3	3	3	3	3
HUGHES	65	46	40	37	73	122	126	116	121	131	65
MBB	16	73	76	76	60	50	50	50	50	12	10
OTHER	44	67	61	63	65	87	77	88	88	74	69
SIKORSKY	99	85	93	112	128	133	135	135	138	185	153
WESTLAND	75	87	77	37	30	130	110	74	75	75	50
TOTAL MILITARY	671	656	679	657	718	921	916	892	941	969	857

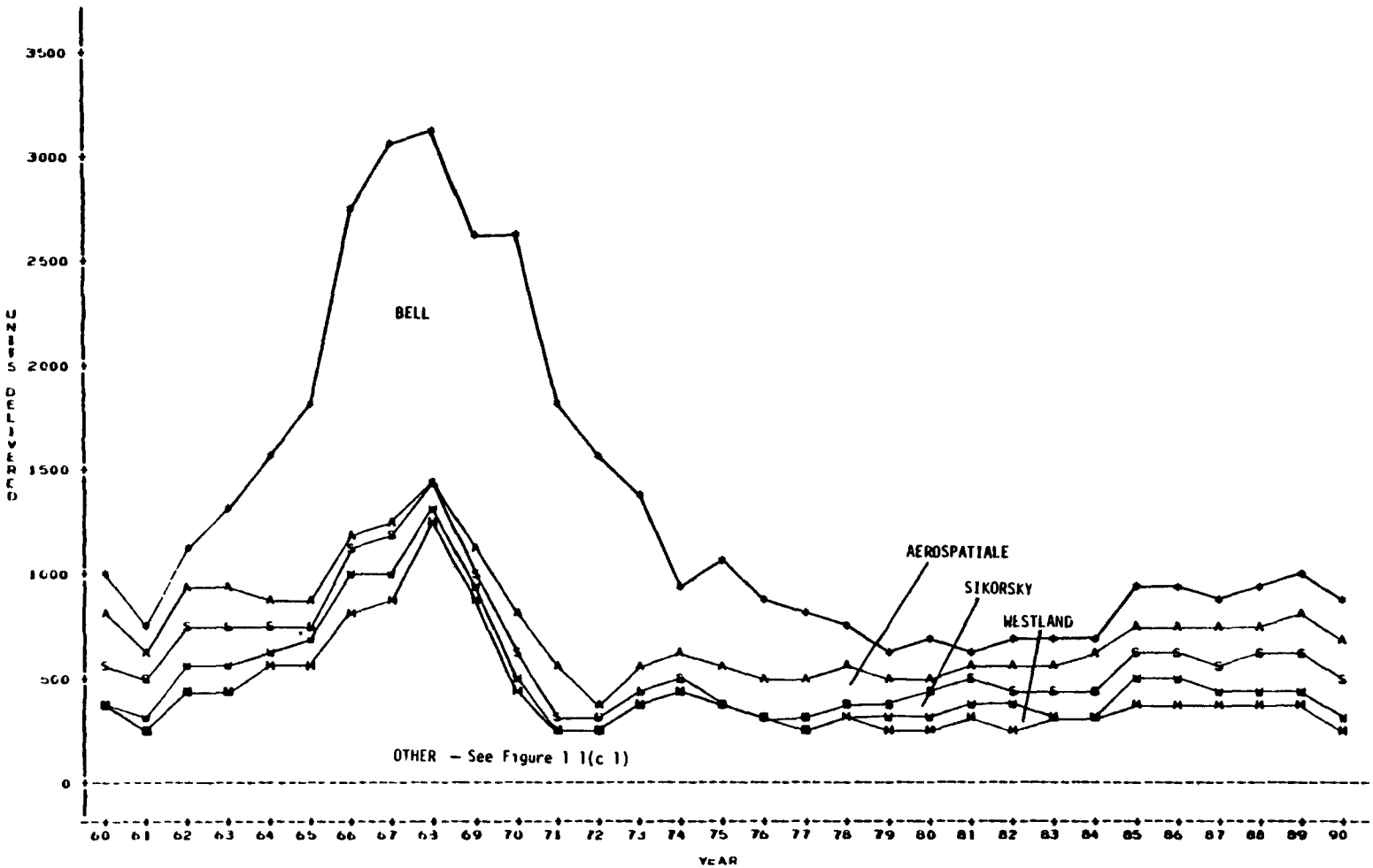

Figure 1.1(c). - Free world military rotorcraft production (units).

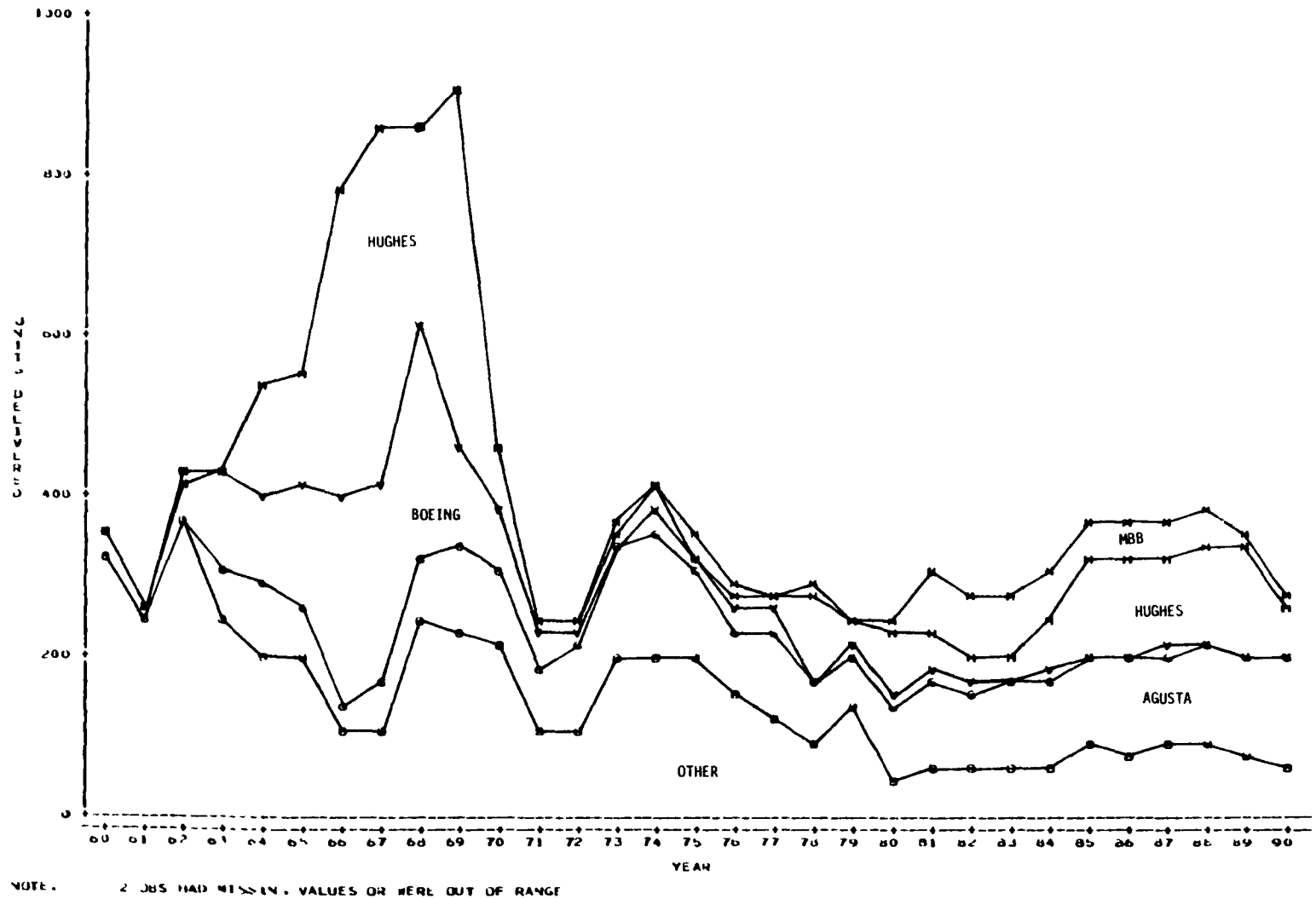

Figure 1.2(c 1). - Free world military rotorcraft production (units).

TABLE 1.1(d). - FREE WORLD MILITARY ROTORCRAFT PRODUCTION ($ MILLIONS)

HISTORY												
	60	61	62	63	64	65	66	67	68	69	70
AEROSPATIALE	24	12	20	21	16	10	12	9	51	51	109
AGUSTA	2	2	2	13	16	16	8	10	19	28	22
BELL HELICOPTER	40	35	40	84	134	193	342	449	721	780	787
BOEING VERTOL	6	6	12	62	133	208	356	332	665	297	172
HUGHES	0	0	0	0	5	5	38	46	68	59	11
MBB	0	0	0	0	0	0	0	0	0	0	0
OTHER	112	83	37	49	42	37	23	31	167	115	215
SIKORSKY	24	67	102	92	69	112	140	302	191	175	245
WESTLAND	5	0	22	32	49	42	54	31	26	12	23
TOTAL MILITARY	207	207	261	374	472	621	973	1209	1848	1518	1583

HISTORY												
	70	71	72	73	74	75	76	77	78	79	80
AEROSPATIALE	109	125	57	84	96	131	140	134	165	105	166
AGUSTA	22	27	38	42	59	49	94	119	118	108	166
BELL HELICOPTER	787	540	408	292	227	429	383	349	272	223	215
BOEING VERTOL	172	104	35	11	92	45	89	80	16	9	72
HUGHES	11	1	1	1	2	1	3	4	16	6	18
MBB	0	0	0	5	0	10	8	1	18	0	14
OTHER	215	85	95	262	167	252	186	166	93	516	25
SIKORSKY	245	97	31	117	149	70	36	23	44	86	292
WESTLAND	23	31	36	30	36	84	69	60	327	404	281
TOTAL MILITARY	1583	1009	761	844	827	1076	1016	937	1068	1458	1251

FORECAST												
	80	81	82	83	84	85	86	87	88	89	90
AEROSPATIALE	166	266	366	463	556	663	775	909	1061	1217	1465
AGUSTA	166	140	171	192	236	257	320	340	384	526	562
BELL HELICOPTER	215	99	185	214	271	361	412	466	582	671	753
BOEING VERTOL	72	94	17	18	20	21	23	25	27	29	31
HUGHES	18	12	13	24	249	628	708	759	862	1065	561
MBB	14	137	146	160	131	143	154	167	180	47	42
OTHER	25	262	67	92	167	244	253	324	323	296	280
SIKORSKY	292	275	321	668	1201	1315	1471	1589	1730	2081	2038
WESTLAND	281	250	241	116	122	404	467	577	617	661	476
TOTAL MILITARY	1251	1535	1569	1947	2977	4116	4583	5162	5766	6587	6088

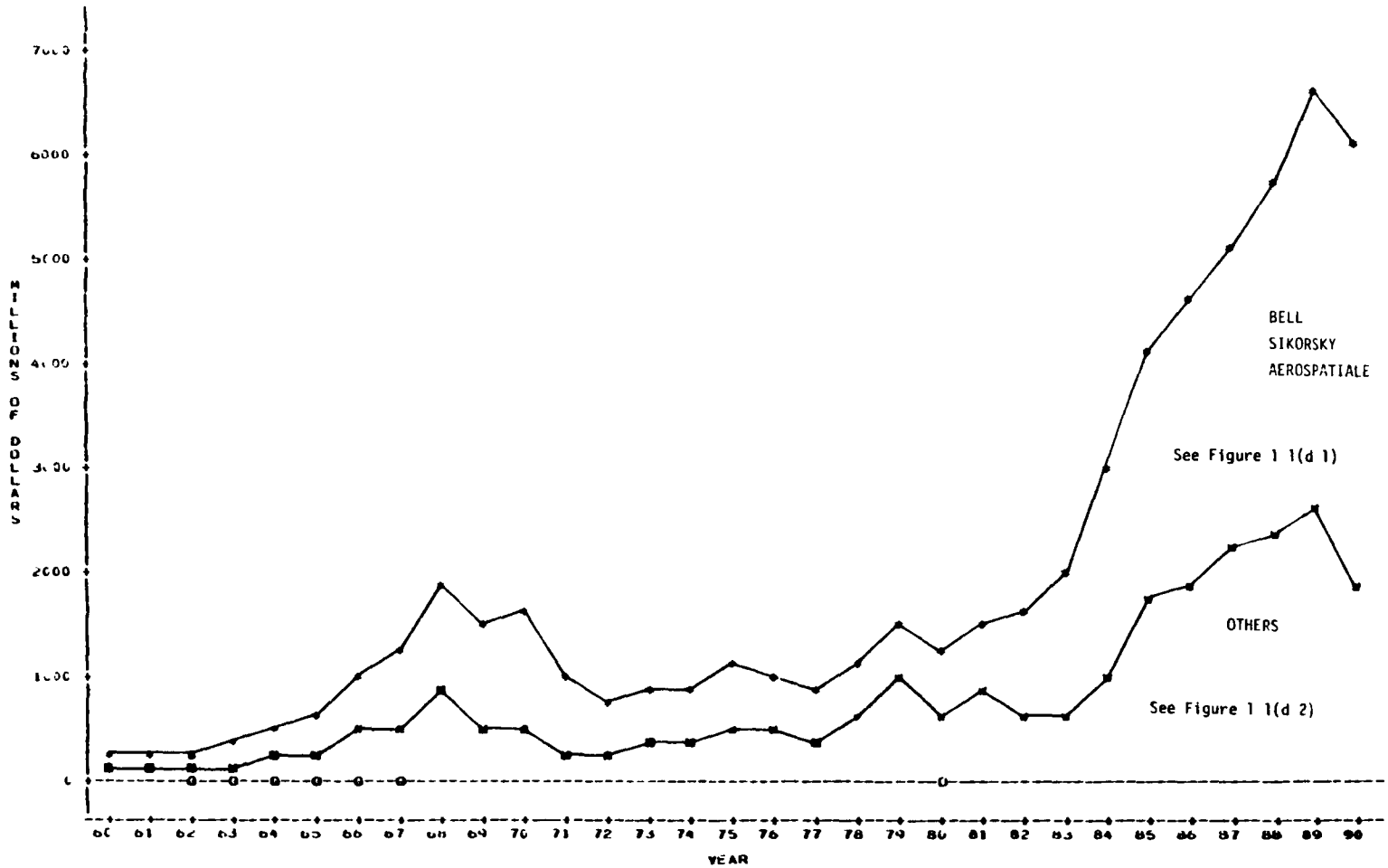

Figure 1.1(d). - Free world military rotorcraft production ($ millions).

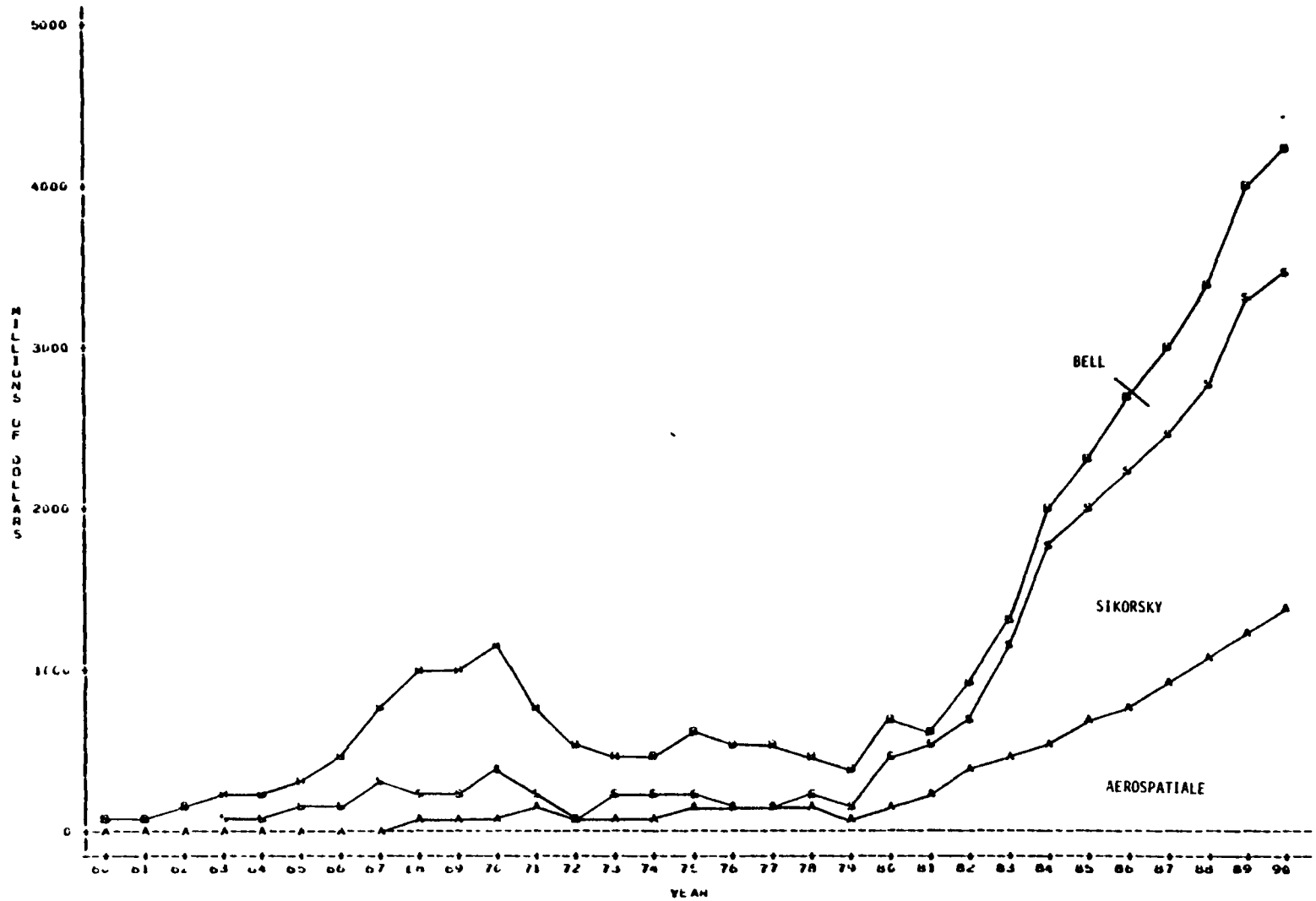

Figure 1.1(d 1). - Free world military rotorcraft production ($ millions).

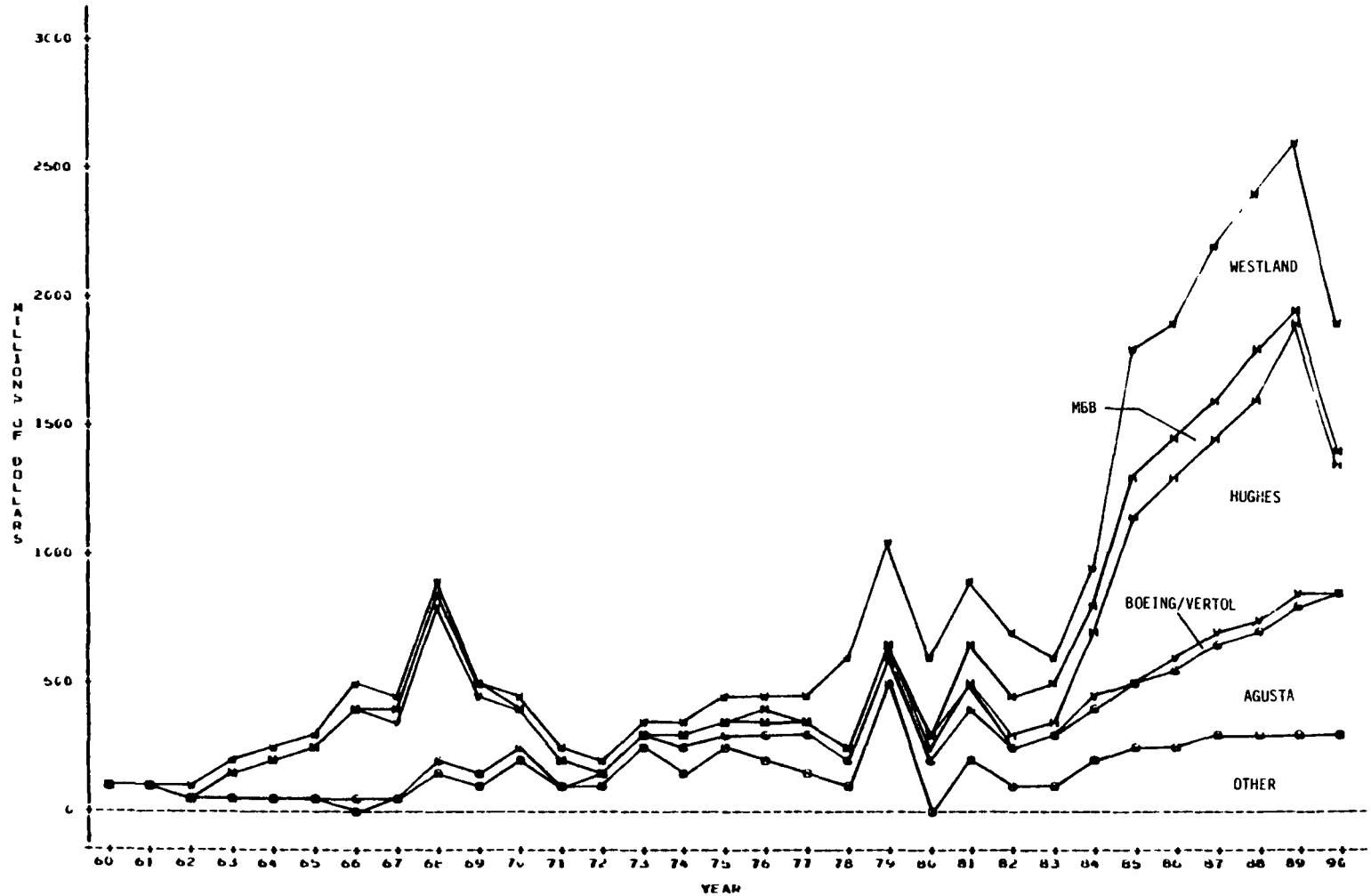

Figure 1.1(d 2). - Free world military rotorcraft production ($ millions).

Growth of License Production (Tables/Figures 1.1 e, f) -U.S.-designed licensed unit production peaked during 1975 at more than 260 units (21% of U.S. production). Thereafter it decreased and is forecast to level at approximately 100 units per year during the 1980/1990 period. European licensed production, starting later than U.S., peaked in 1974 at 104 units per year (32% of European production). Thereafter it also declined to approximately 50 units per year. Aerospatiale and MBB are now pursuing aggressive licensing programs (Brazil/Indonesia/Japan/China) and licensed production of European design is expected to grow moderately again reaching 75 units per year by 1990.

Licensed production occurs when countries want to procure technology. It is hampered by the very high cost of tooling and technical know how amortized over a relatively low production run to satisfy a single country's force requirements.

TABLE 1.1(e). - GROWTH OF LICENSE PRODUCTION (UNITS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
EURO D GN/EURO PROD	295	159	260	244	145	110	175	116	131	206	403
EURO D GN/LIC PROD	0	6	10	9	10	10	10	8	10	10	22
U.S. D GN/LIC PROD	156	167	222	191	255	265	251	330	379	361	260
U.S. D GN/U.S. PROD	739	765	1027	1326	1628	1851	2709	3122	3146	2592	2474
TOTAL FREE WORLD	1192	1091	1519	1770	2038	2242	3145	3576	3666	3169	3159

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
EURO D GN/EURO PROD	403	340	166	379	323	349	349	339	402	515	594
EURO D GN/LIC PROD	22	35	41	56	104	81	56	87	56	42	27
U.S. D GN/LIC PROD	260	219	255	249	260	262	160	174	152	149	121
U.S. D GN/U.S. PROD	2474	1766	1747	1719	1153	1233	1117	979	1008	1294	1628
TOTAL FREE WORLD	3159	2366	2209	2403	1640	1925	1704	1579	1618	2000	2370

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
EURO D GN/EURO PROD	594	693	722	735	755	840	855	904	940	937	945
EURO D GN/LIC PROD	27	59	79	75	71	121	125	73	73	73	73
U.S. D GN/LIC PROD	121	130	106	101	103	125	99	110	106	96	91
U.S. D GN/U.S. PROD	1626	1618	1724	1637	2010	2204	2327	2435	2547	2726	2743
TOTAL FREE WORLD	2370	2500	2631	2751	2939	3290	3404	3522	3666	3832	3852

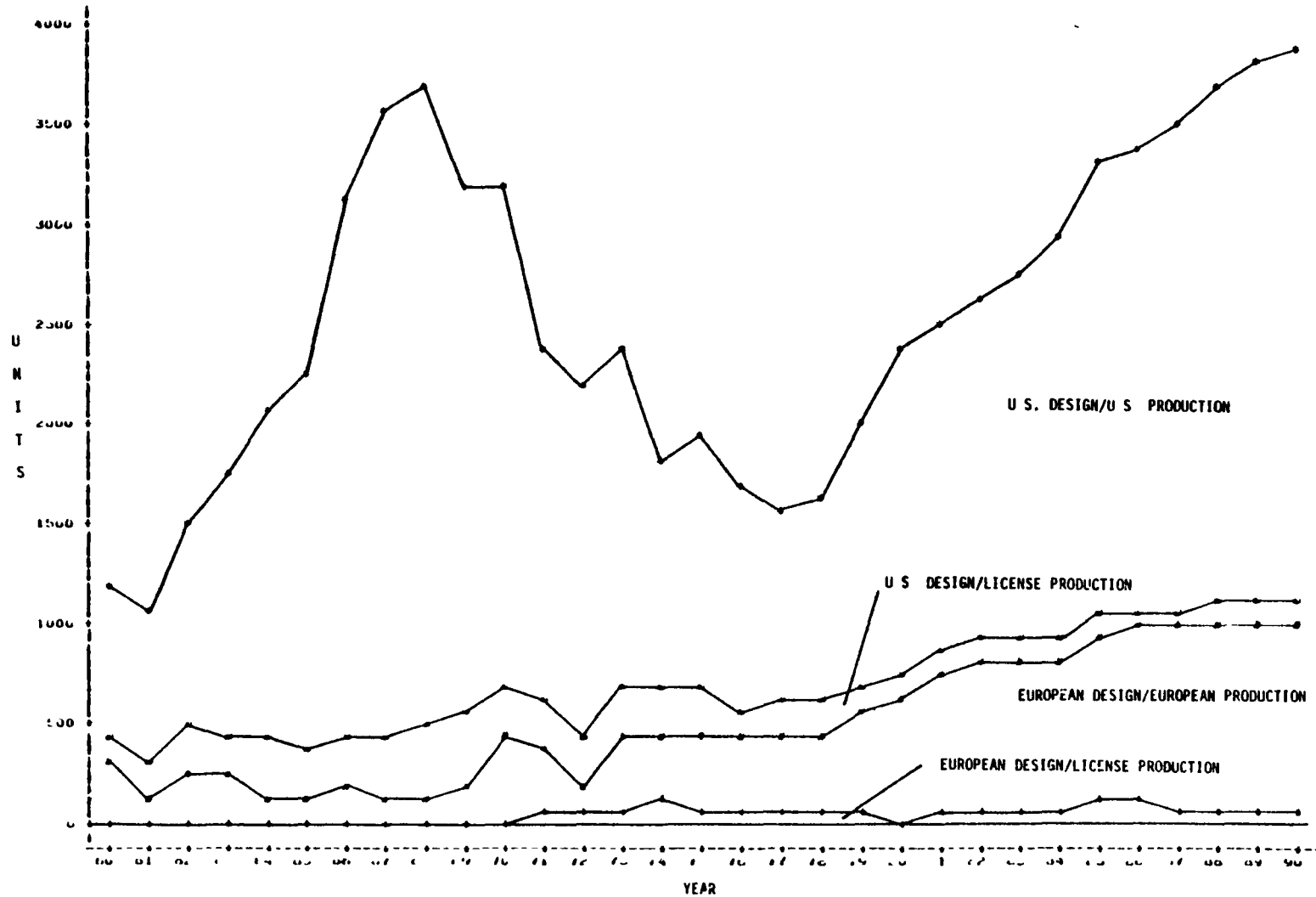

Figure 1.1(e). - Growth of license production (units).

TABLE 1.1(f). - GROWTH OF LICENSE PRODUCTION ($ MILLIONS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
EURO DSGN/EURO PROD	94	61	36	36	26	20	46	25	169	119	263
EURO DSGN/LIC PROD	0	0	2	2	2	2	2	0	2	2	14
U.S. DSGN/LIC PROD	19	19	26	41	73	69	66	67	104	103	92
U.S. DSGN/U.S. PROD	108	146	225	330	407	570	906	1170	1650	1366	1282
TOTAL FREE WORLD	222	226	290	410	507	661	1020	1262	1926	1610	1650

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
EURO DSGN/EURO PROD	263	169	106	220	245	345	296	349	650	1031	682
EURO DSGN/LIC PROD	14	23	17	13	27	25	19	29	21	40	15
U.S. DSGN/LIC PROD	92	106	131	141	152	214	232	205	199	250	208
U.S. DSGN/U.S. PROD	1282	799	536	570	638	752	701	643	564	617	1155
TOTAL FREE WORLD	1650	1096	792	1043	1059	1337	1249	1226	1433	2007	2060

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
EURO DSGN/EURO PROD	662	947	1115	1175	1314	1652	2046	2426	2733	2926	3052
EURO DSGN/LIC PROD	15	66	102	119	125	164	280	269	290	407	440
U.S. DSGN/LIC PROD	208	367	165	165	291	356	267	340	340	314	299
U.S. DSGN/U.S. PROD	1155	1234	1487	2046	3039	3816	4327	4866	5506	6553	6440
TOTAL FREE WORLD	2060	2614	2869	3507	4769	6188	6920	7903	8869	10200	10231

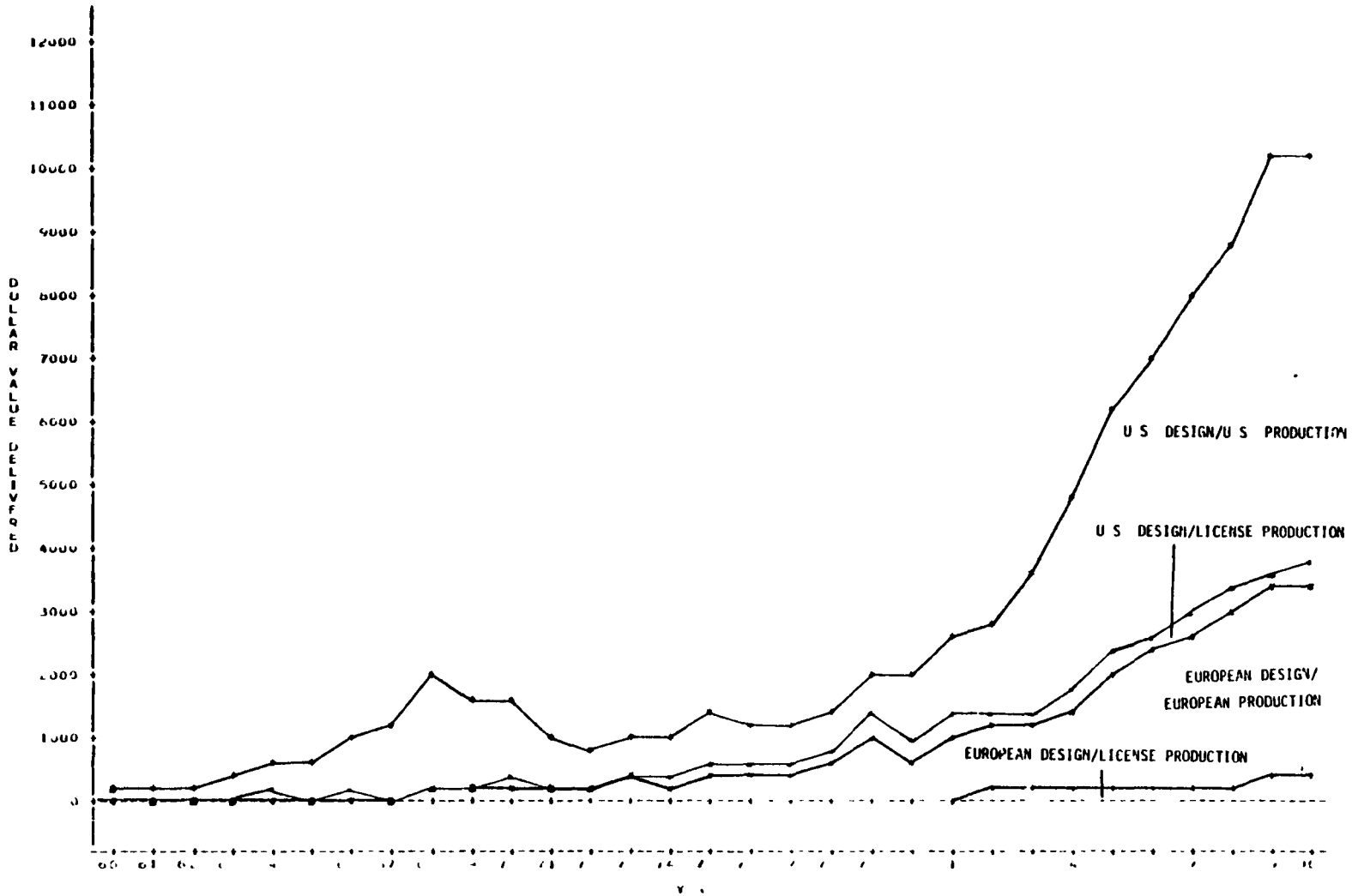

Figure 1.1(f). - Growth of license production ($ millions).

Free World Direct Employment (Table/Figure 1.1g) - During the 1960's, direct labor employment rose to a peak at the height of the Vietnam War, led by U.S. manufacturers. During the post-Vietnam years, employment dropped dramatically. It has subsequently resumed a growth pattern resulting from increased unit production. By 1990, employment is expected to increase substantially, even taking into account improved manufacturing techniques and increased employee productivity. It is important to note that, due to personnel accounting methods employed in the industry, the figures shown include the direct labor to produce spares as well as end item helicopters. As inventories grow, and helicopter complexity increases, spare parts support requirements become increasingly significant as part of manufacturers direct labor.

TABLE 1.1(g). - FREE WORLD CIVIL & MILITARY ROTORCRAFT PRODUCTION
(DIRECT EMPLOYEES)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
U.S.	8418	8801	11189	12425	12864	14575	18253	19227	19600	17829	14408
FOREIGN	4673	4988	6186	6125	7777	8342	8895	9296	10715	10246	9800
TOTAL U.S. & FOREIGN	13091	13789	17375	18550	20641	22917	27148	28523	30315	28075	24208

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
U.S.	14408	10607	8878	9269	10714	12091	11642	10317	11075	13175	14675
FOREIGN	9800	10355	10315	11351	10385	10691	10903	9740	11217	9736	9222
TOTAL U.S. & FOREIGN	24208	20962	19193	20620	21099	22782	22545	20057	22292	22911	23897

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
U.S.	14675	15360	15247	16993	19238	21762	22166	22918	23842	28150	25475
FOREIGN	9222	12115	12483	12569	13085	14768	15072	16051	16795	16420	16009
TOTAL U.S. & FOREIGN	23897	27475	27730	29562	32323	36530	37238	38969	40637	44570	41484

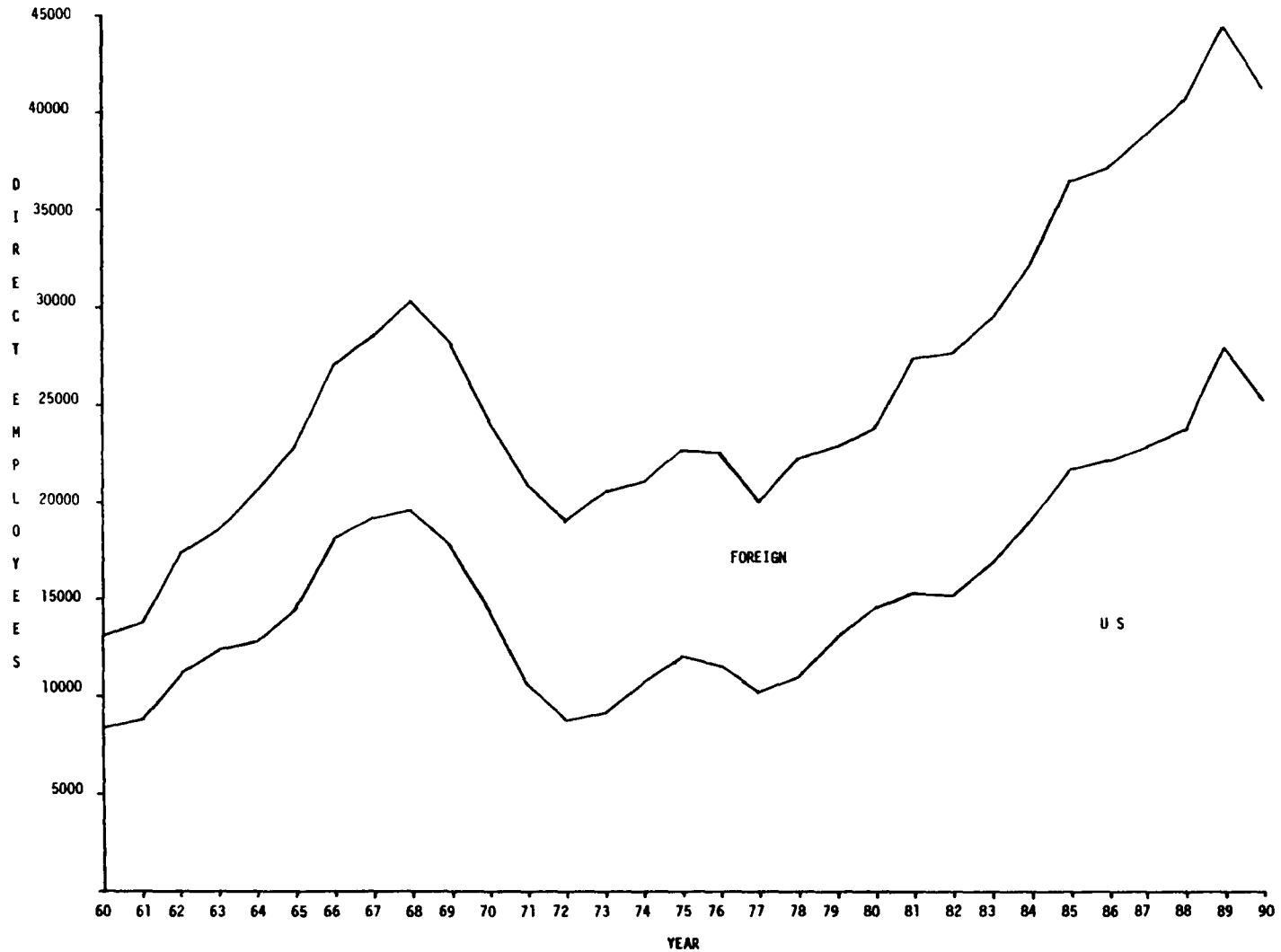

Figure 1.1(g). - Free world civil & military rotorcraft production (direct employees).

Task 1.2 - Regional market consumption and growth for civil and military rotorcraft for the period 1960 through 1990.

Regional Civil Markets (Tables/Figures 1.2 a & b) - The U.S. civil rotorcraft market dominates the free world, accounting for more than one-half of the market over the past twenty years. All regions, other than the Middle East, reflect a temporary decrease after the fivefold oil price increase in 1973/74 before resuming their climb beginning in 1978. The U.S. dominance is expected to hold throughout the forecast period. Latin America, Europe, and Australia/Asia all are expected to show strong growth.

The regional distribution reflects the high demand for helicopters for exploration and development of energy in the U.S., Mexico, Brazil, the North Sea, the Persian Gulf, and the archaepelago stretching 3000 miles from Thailand to Australia. It also reflects the wealth of countries with a surplus of oil as discussed in Enclosure I.

Figure 1.2(a 1) is an expansion of 1.2(a) without the U.S. shown.

TABLE 1.2(a). - REGIONAL CIVIL MARKETS (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
AUSTRALIA/ASI	25	37	20	37	66	47	33	100	54	94	98
CANADA	29	29	28	25	22	46	45	45	64	52	57
EUROPE	13	22	39	66	56	68	40	65	97	96	84
LATIN AMERICA	4	9	29	21	35	59	33	43	50	50	63
MID EAST/AFRI	3	1	6	11	18	4	6	13	18	8	30
UNITED STATES	96	142	164	229	229	164	228	236	282	247	210
UNKNOWN	52	90	84	61	54	33	28	6	4	3	6
TOTAL CIVIL	222	330	370	450	480	421	413	508	569	550	548

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
AUSTRALIA/ASI	98	66	69	104	101	101	105	94	127	144	182
CANADA	57	81	87	101	70	78	60	63	54	98	164
EUROPE	84	92	127	170	145	141	99	107	145	143	228
LATIN AMERICA	63	45	50	56	52	63	80	101	66	89	149
MID EAST/AFRI	30	50	23	34	32	37	47	36	48	27	89
UNITED STATES	210	216	264	559	489	425	404	352	392	635	867
UNKNOWN	6	8	5	16	24	16	7	6	5	10	0
TOTAL CIVIL	548	558	625	1040	913	861	802	759	837	1346	1699

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
AUSTRALIA/ASI	182	210	181	222	239	258	273	289	281	301	313
CANADA	164	236	257	266	282	295	307	325	339	354	368
EUROPE	228	236	256	271	290	301	311	328	344	358	370
LATIN AMERICA	149	152	162	170	175	187	195	207	217	231	243
MID EAST/AFRI	89	107	105	117	116	118	123	129	132	138	146
UNITED STATES	887	910	991	1048	1119	1210	1277	1352	1412	1481	1555
UNKNOWN	0	0	0	0	0	0	0	0	0	0	0
TOTAL CIVIL	1699	1851	1952	2094	2221	2369	2486	2630	2725	2863	2995

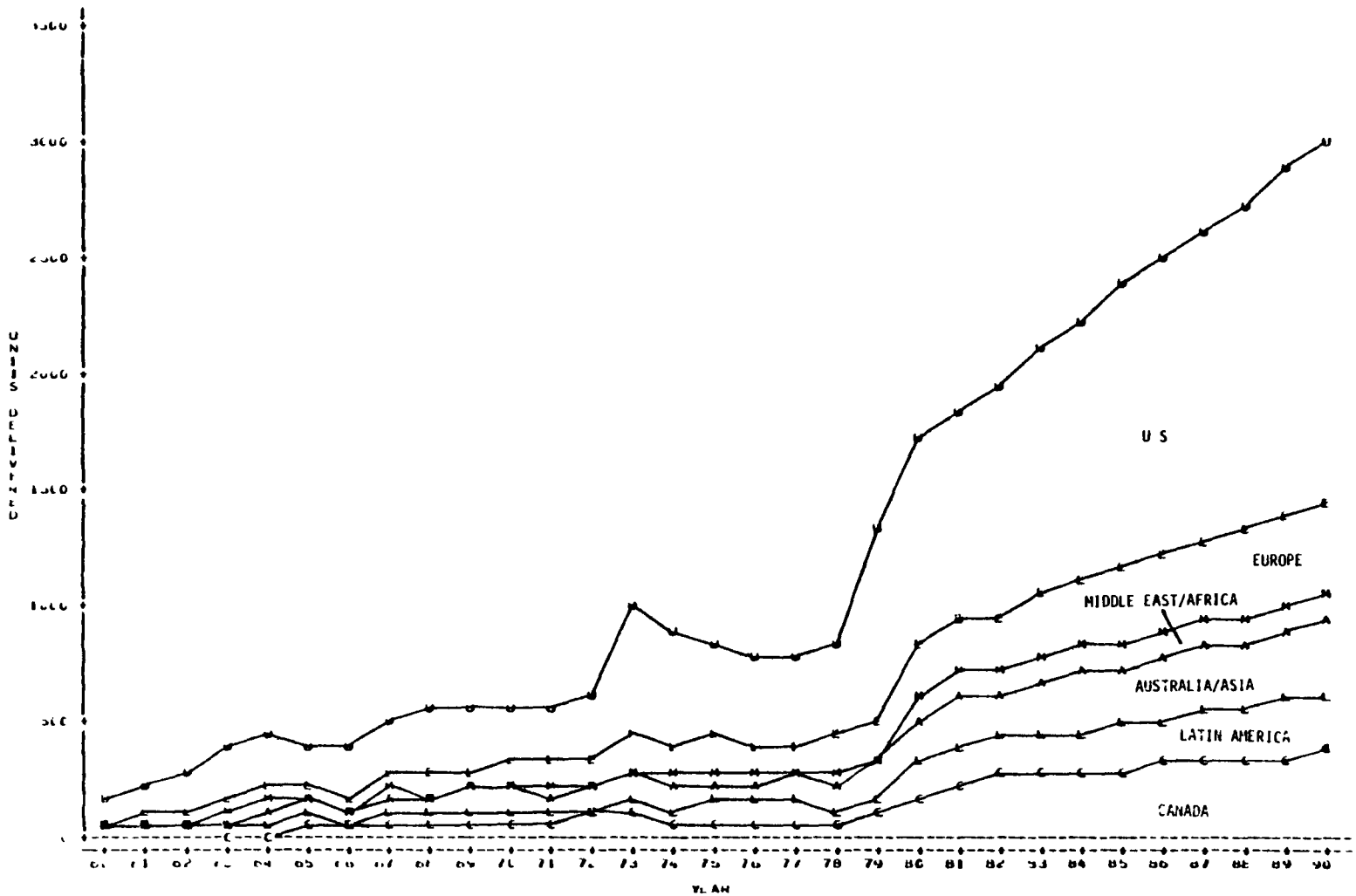

Figure 1.2(a). - Regional civil markets (units).

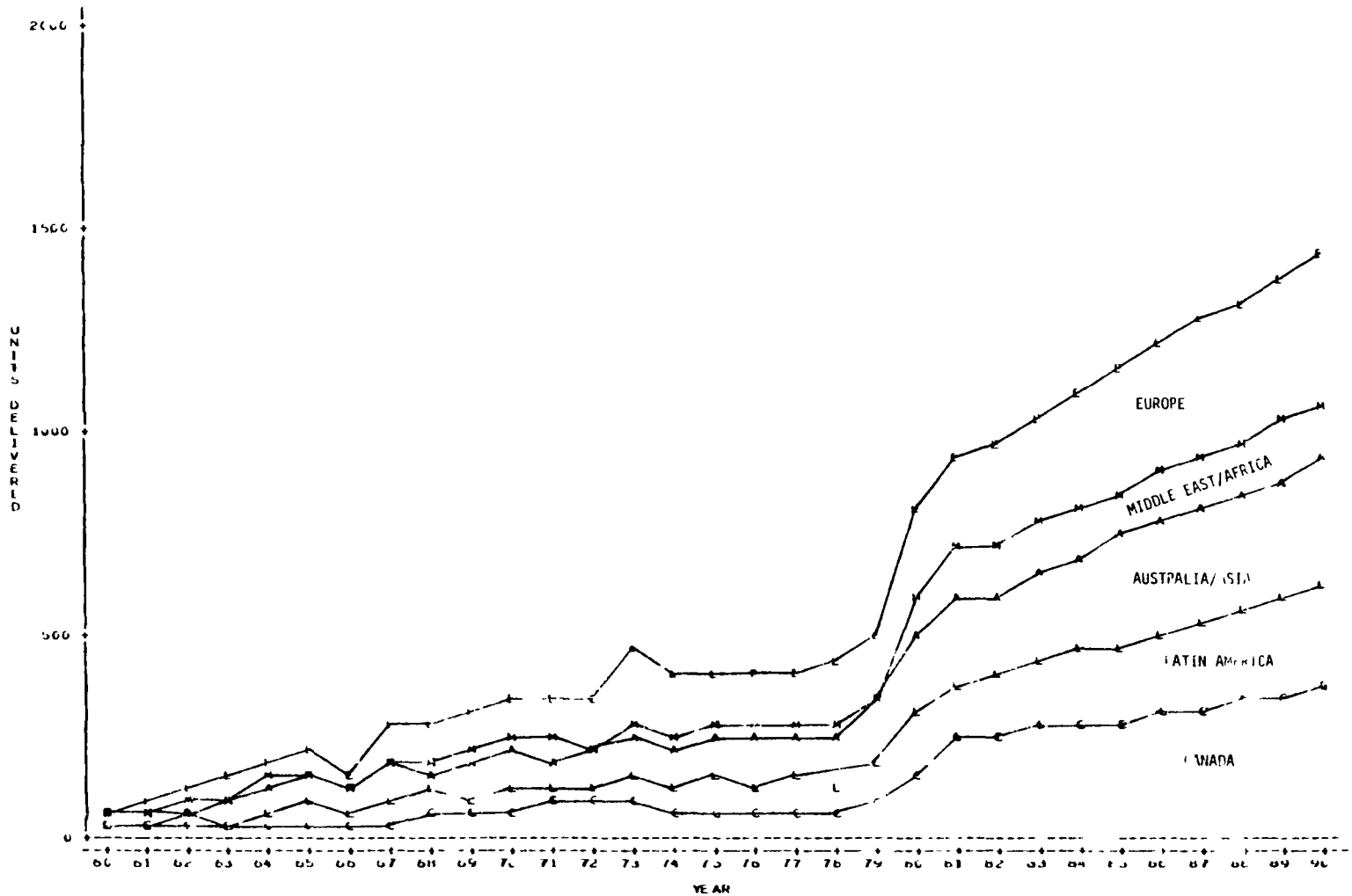

Figure 1.2(a 1). - Regional civil markets (units).

TABLE 1.2(b). - REGIONAL CIVIL MARKETS ($ MILLIONS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
AUSTRALIA/ASI	1	2	3	3	5	5	3	14	6	20	12
CANADA	3	2	2	1	1	4	4	4	5	7	8
EUROPE	1	4	3	6	8	8	7	6	13	16	12
LATIN AMERICA	0	1	1	2	2	4	2	3	5	6	7
MID EAST/AFRI	0	0	1	3	2	1	0	1	3	3	4
UNITED STATES	7	7	15	18	14	16	16	24	46	42	24
UNKNOWN	3	5	4	3	2	2	1	0	0	0	0
TOTAL CIVIL	15	19	29	36	35	40	35	53	78	93	67

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
AUSTRALIA/ASI	12	10	17	23	36	28	32	30	53	65	77
CANADA	6	11	17	17	15	19	17	19	18	39	65
EUROPE	12	16	28	43	64	66	45	66	112	102	125
LATIN AMERICA	7	6	8	15	16	26	21	36	25	46	86
MID EAST/AFRI	4	14	5	9	7	13	23	27	35	23	55
UNITED STATES	24	27	36	92	94	105	100	107	121	267	400
UNKNOWN	0	1	1	1	2	3	1	4	6	5	0
TOTAL CIVIL	67	88	111	200	233	260	239	288	365	546	808

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
AUSTRALIA/ASI	77	106	135	149	184	222	252	292	317	377	435
CANADA	65	113	139	168	203	227	249	294	319	360	419
EUROPE	125	145	210	230	319	354	397	455	576	677	760
LATIN AMERICA	86	78	97	116	130	154	185	225	282	335	383
MID EAST/AFRI	55	65	81	88	93	113	126	140	175	205	242
UNITED STATES	400	561	708	809	864	1001	1126	1334	1346	1661	1905
UNKNOWN	0	0	0	0	0	0	0	0	0	0	0
TOTAL CIVIL	808	1070	1320	1560	1793	2071	2337	2740	3015	3615	4144

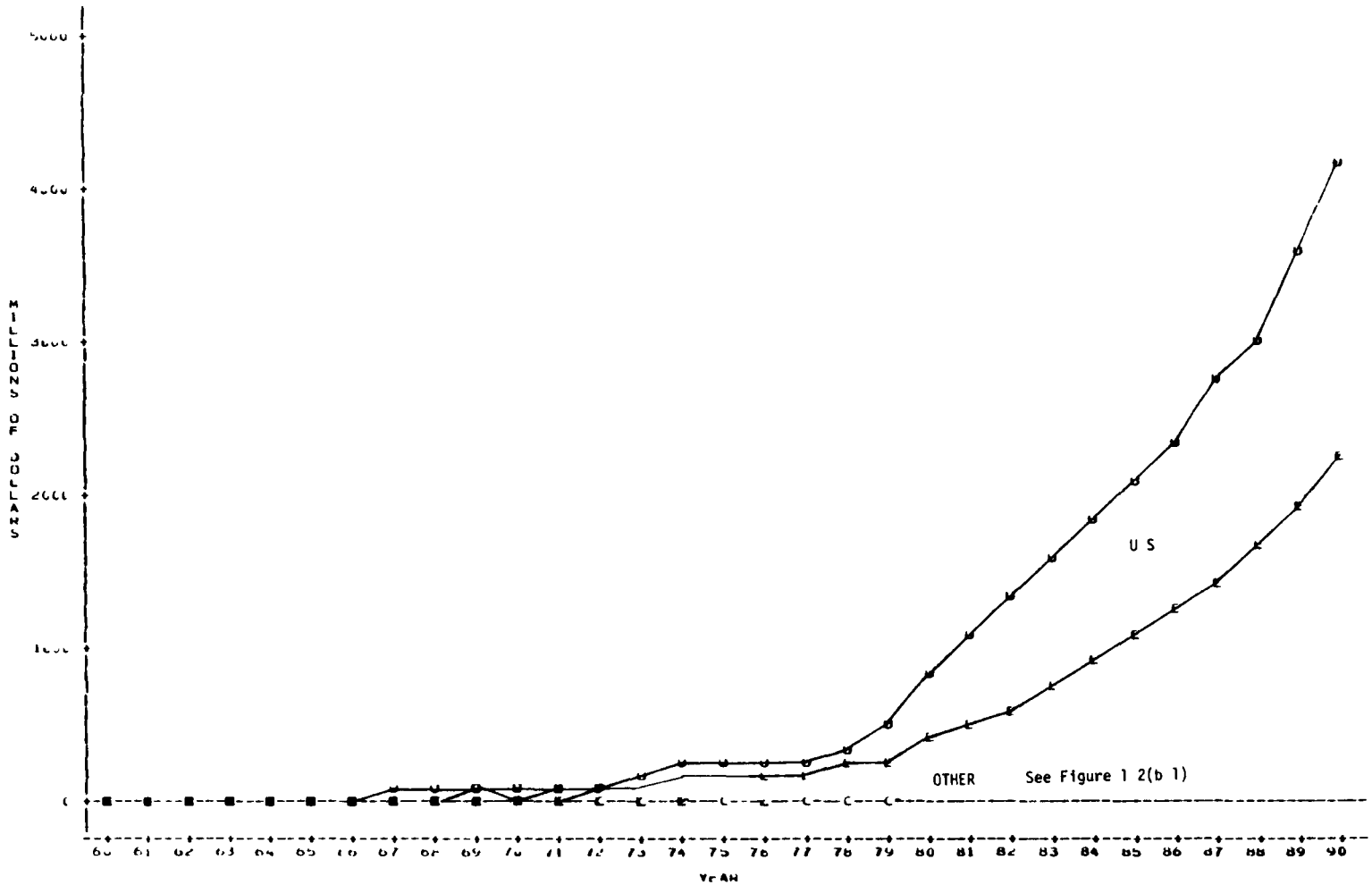

Figure 1.2(b). - Regional civil markets ($ millions).

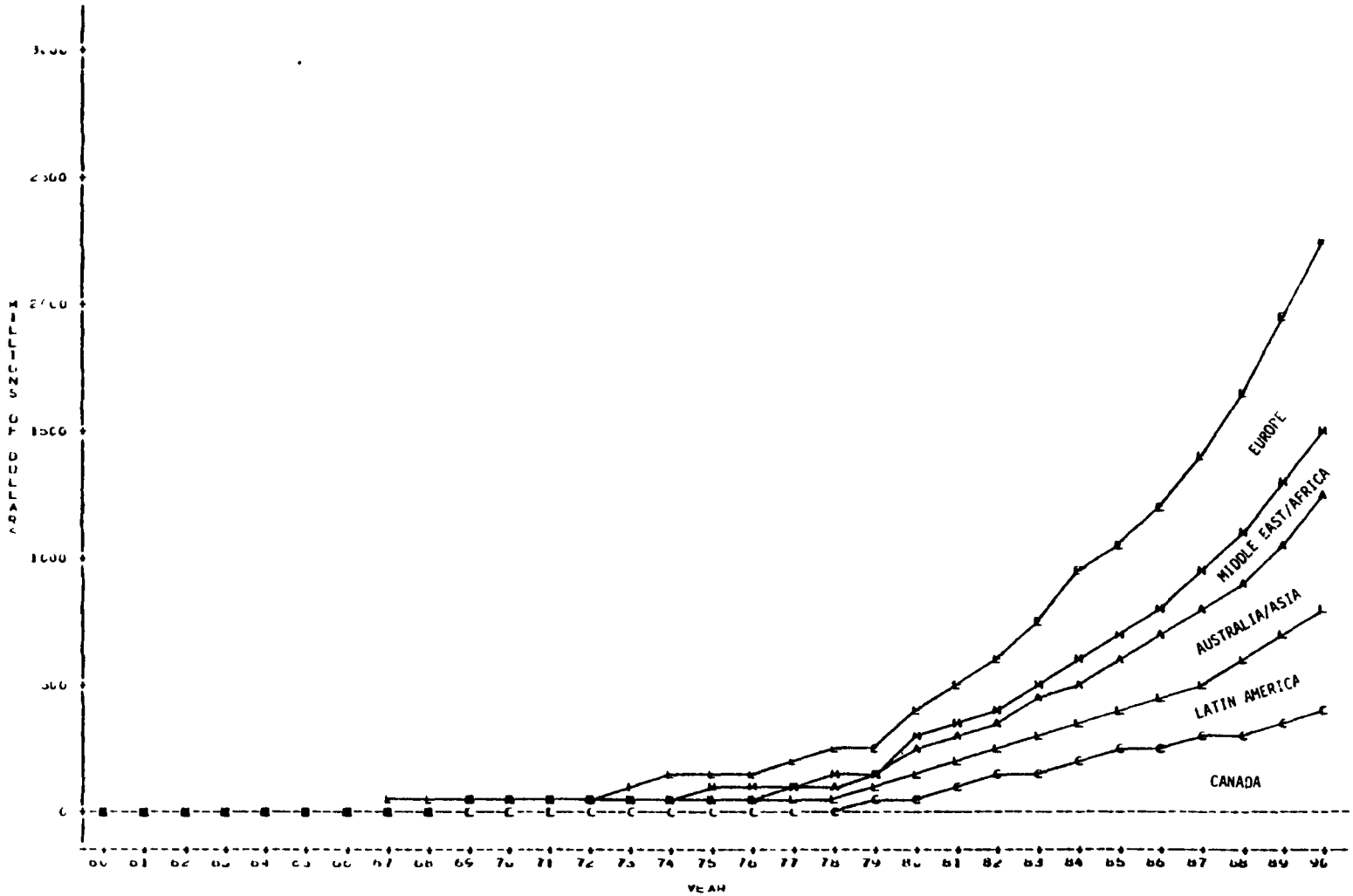

Figure 1.2(b 1). - Regional civil markets ($ millions).

Regional Military Markets (Tables/Figures 1.2 c & d) - During the past two decades, the U.S. was predominate in military rotorcraft markets due primarily to the introduction of air mobile forces in the Vietnam War. The European market has remained relatively steady at 200 to 400 units per year reflecting force modernization for NATO. Latin America has remained relatively static at a low level. Australia and Asia have shown a steady increase over the period, reflecting force build-up of free world countries to offset U.S. withdrawal. The most abrupt change is in the Middle East which occurred in two steps in 1968 and 1973. This reflects the creation of the United Arab Emirates forces replacing the U.K. forces under the Trucial States accord and also the wealth created by the fivefold increase in the price of oil in 1973. By the end of the forecast period, Europe and Middle East/Africa will be the leading markets followed by the U.S. and Australia/Asia.

TABLE 1.2(c). - REGIONAL MILITARY MARKETS (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
AUSTRALIA/ASI	56	51	95	75	63	31	140	96	155	197	150
CANADA	0	0	0	16	25	14	7	5	16	4	0
EUROPE	327	227	393	405	264	244	322	294	281	279	386
LATIN AMERICA	26	31	22	16	27	30	26	18	35	78	34
MID EAST/AFRI	61	26	36	32	79	47	49	66	136	136	102
UNITED STATES	500	431	599	782	1098	1466	2182	2583	2472	1928	1686
TOTAL MILITARY	970	766	1148	1326	1556	1822	2732	3062	3095	2622	2612

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
AUSTRALIA/ASI	150	163	142	141	163	134	108	150	226	157	96
CANADA	0	44	79	0	8	0	1	0	0	0	0
EUROPE	386	304	201	230	259	250	219	198	174	217	248
LATIN AMERICA	34	10	41	73	87	25	65	40	71	31	54
MID EAST/AFRI	162	98	82	233	207	424	373	346	188	119	93
UNITED STATES	1880	1250	1037	686	202	230	134	88	127	126	178
TOTAL MILITARY	2612	1869	1582	1363	926	1063	900	822	786	650	671

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
AUSTRALIA/ASI	96	87	118	92	98	134	122	128	140	118	132
CANADA	0	14	0	5	10	24	0	0	15	20	10
EUROPE	241	310	284	265	259	353	348	337	334	330	314
LATIN AMERICA	54	47	57	75	76	64	69	77	95	83	83
MID EAST/AFRI	93	85	106	93	107	110	114	97	119	136	147
UNITED STATES	176	107	112	127	168	236	265	253	238	282	171
TOTAL MILITARY	671	650	679	657	718	921	918	892	941	969	857

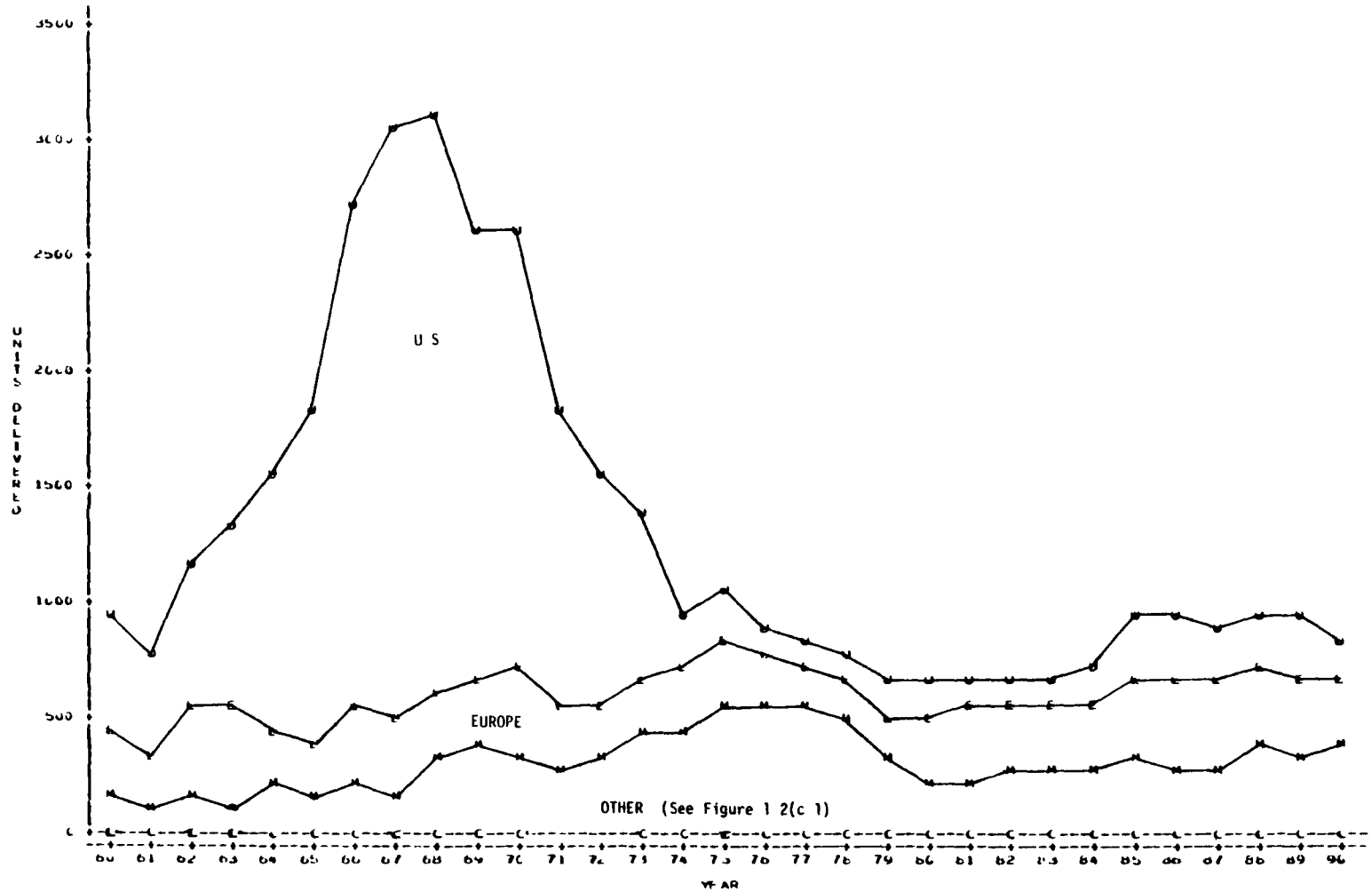

Figure 1.2(c). - Regional military markets (units).

TABLE 1.2(d). - REGIONAL MILITARY MARKET ($ MILLIONS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
AUSTRALIA/ASI	5	51	12	19	19	23	69	43	70	101	62
CANADA	3	0	3	19	33	14	7	5	5	4	0
EUROPE	95	27	58	86	76	67	83	61	96	85	104
LATIN AMERICA	3	6	2	1	3	4	4	4	10	17	13
MID EAST/AFRI	13	4	7	5	17	10	12	36	169	106	165
UNITED STATES	89	120	182	243	323	498	743	1057	1494	1205	1140
TOTAL MILITARY	207	207	261	374	472	622	973	1209	1847	1519	1583

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
AUSTRALIA/ASI	62	61	93	83	191	110	101	155	175	227	86
CANADA	0	27	18	0	24	0	1	0	0	0	0
EUROPE	124	193	163	221	219	218	160	168	413	517	594
LATIN AMERICA	13	7	16	47	36	20	76	91	39	41	49
MID EAST/AFRI	165	75	87	263	175	503	442	406	224	472	131
UNITED STATES	1140	640	422	231	179	214	106	117	164	202	351
TOTAL MILITARY	1503	1009	780	844	827	1076	1004	937	1061	1458	1251

FORECAST

	81	82	83	84	85	86	87	88	89	90
AUSTRALIA/ASI	236	179	193	312	376	344	492	540	562	651
CANADA	4	0	11	24	75	0	0	111	165	80
EUROPE	747	665	605	662	1132	1342	1477	1706	1951	1975
LATIN AMERICA	52	133	137	151	156	143	251	289	335	342
MID EAST/AFRI	191	276	302	370	441	416	485	605	703	900
UNITED STATES	384	344	444	1457	1953	2236	2498	2532	2939	2141
TOTAL MILITARY	1556	1569	1947	2976	4113	4533	5103	5784	6585	6089

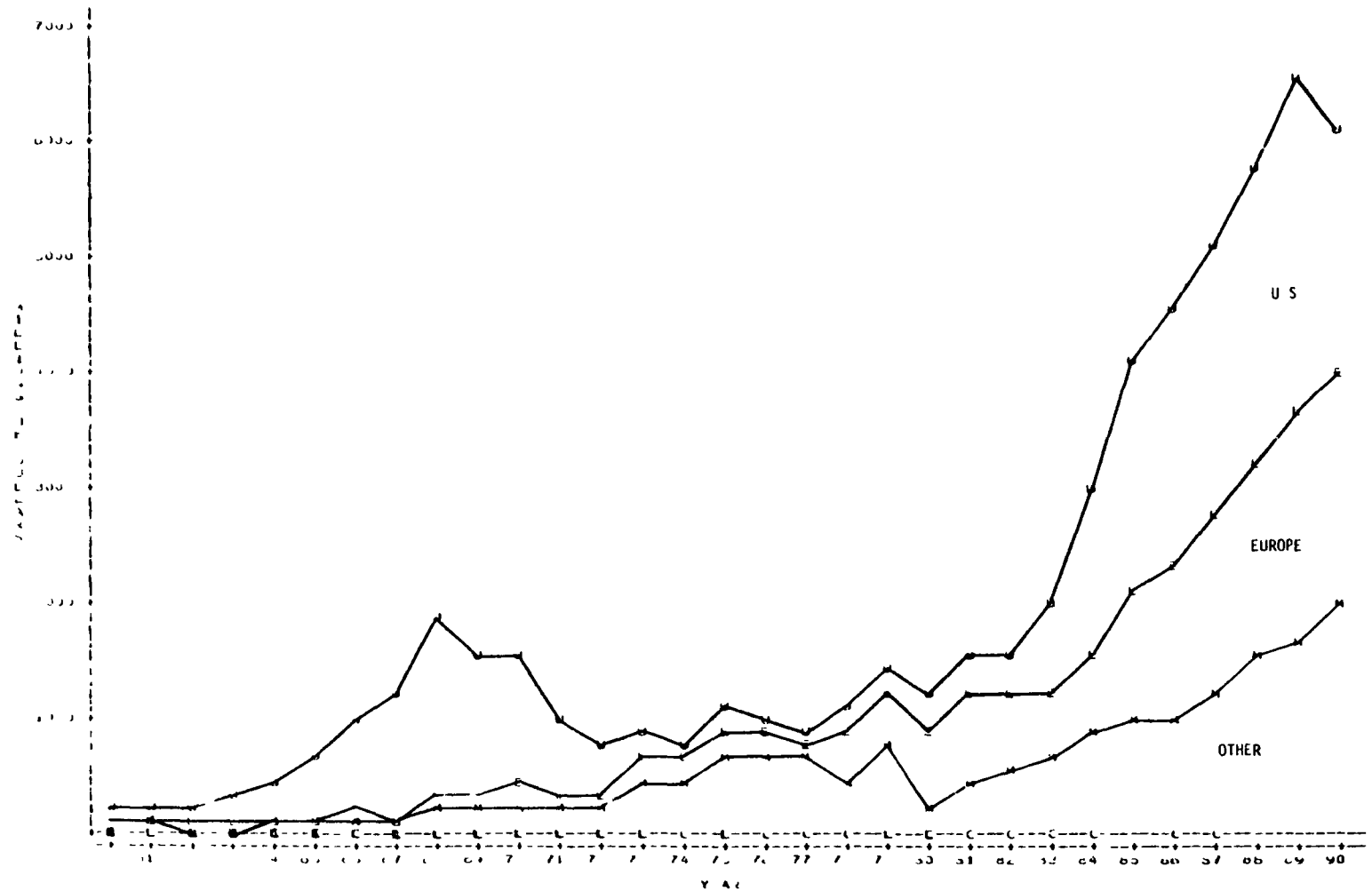

Figure 1.2(d). - Regional military markets ($ millions).

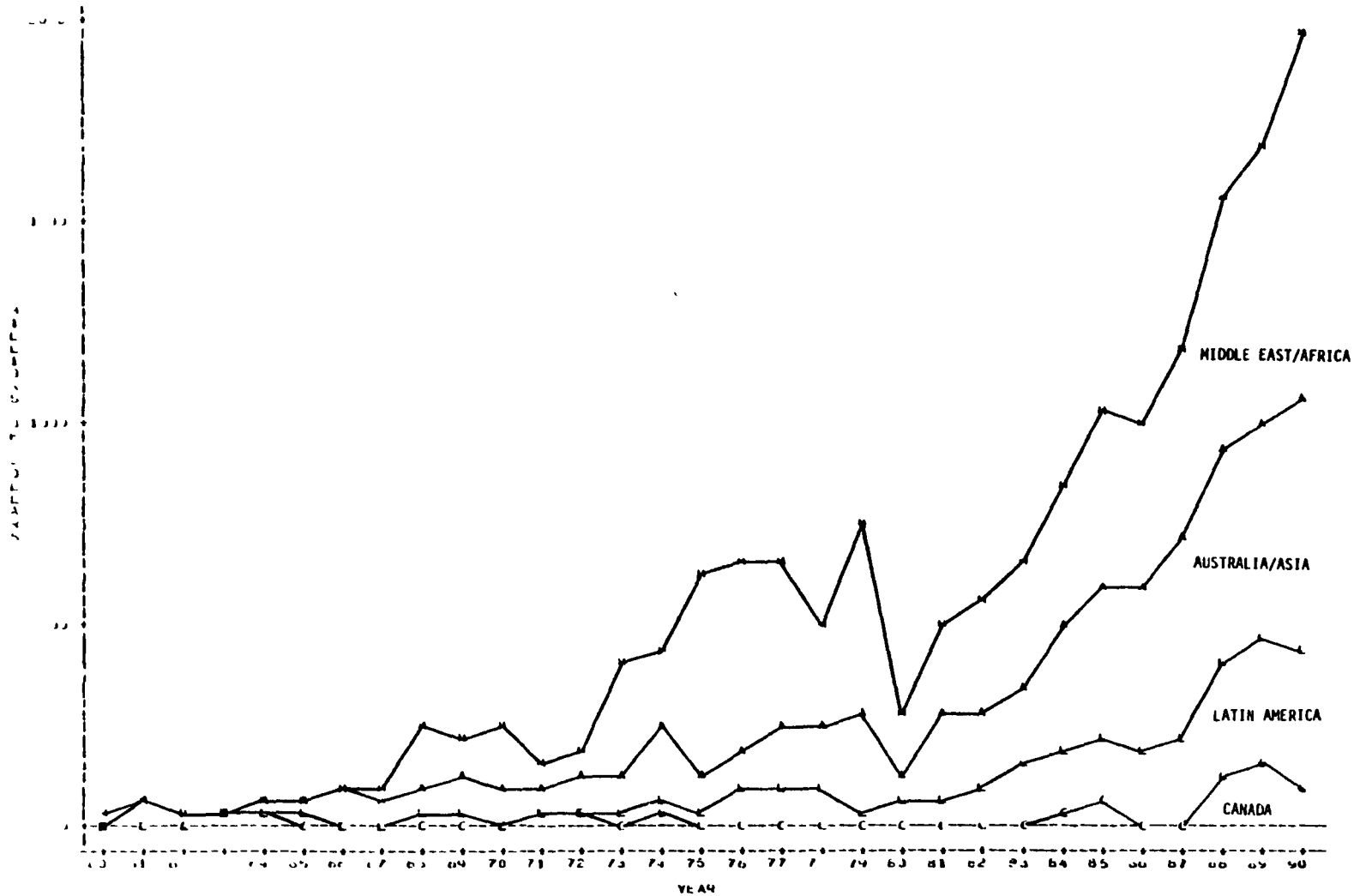

Figure 1.2(d 1). - Regional military markets ($ millions).

Task 1.3 - Free World market consumption and growth for civil and military rotorcraft by vehicle type:

Piston	
Light Single Engine Turbine	(0 - 10,000 #)
Light Twin Engine Turbine	(5,000 - 10,000 #)
Medium Single Engine Turbine	(8,000 - 15,000 #)
Medium Twin Engine Turbine	(10,000 - 25,000 #)
Heavy Multi Engine Turbine	(20,000 -100,000 #)
Armed	(3,000 - 20,000 #)

Civil Rotorcraft Market (Tables/Figures 1.3 a & b) - The light single engine helicopter has dominated the civil rotorcraft market from the outset, turbines taking over from pistons toward the end of the 1960's. It showed vigorous growth until the 1973/74 oil price increase. This growth resumed again in 1979. The requirements for twin engine reliability for executives is reflected by the introduction of light twins in 1971. The rapid growth of medium twins is a result of the explosion in offshore oil exploration and development beginning in the 1970's. The medium single turbine which dominated the medium market in the 1960's, was over taken by the medium twin in the 1970's, and will drop out of production in 1981 with the last of the Bell Model 205A-1 production. Most of the medium twins are in the resource exploration market. For the future, the light twin will show the greatest rate of growth, followed by the light single turbine, and the medium turbine, in that order.

TABLE 1.3(a). - CIVIL ROTORCRAFT MARKET (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
HEAVY MULTI	0	0	3	1	0	3	0	0	1	1	0
LIGHT SINGLE	4	7	22	32	34	40	32	202	282	263	301
LT/MED TWIN	0	0	0	0	0	0	0	0	1	0	0
MEDIUM MULTI	0	1	6	3	5	5	7	4	18	21	7
MEDIUM SINGLE	4	6	19	29	15	11	12	28	36	44	25
PISTON	214	317	320	385	426	360	362	274	231	220	214
TOTAL CIVIL	222	331	370	450	480	423	413	508	569	549	547

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
HEAVY MULTI	0	0	1	5	2	2	0	0	2	0	0
LIGHT SINGLE	301	317	382	613	541	513	451	475	539	841	997
LT/MED TWIN	0	10	22	24	43	32	24	26	61	59	181
MEDIUM MULTI	7	24	41	68	83	102	59	74	71	113	169
MEDIUM SINGLE	25	24	19	22	30	32	43	13	22	20	12
PISTON	214	183	160	308	213	181	226	169	143	266	340
TOTAL CIVIL	547	558	625	1040	914	862	803	757	838	1350	1699

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
HEAVY MULTI	0	1	3	3	4	4	4	4	4	4	4
LIGHT SINGLE	997	1055	1101	1195	1294	1394	1492	1585	1645	1733	1817
LT/MED TWIN	181	223	273	318	349	383	390	416	437	460	486
MEDIUM MULTI	169	201	216	214	204	213	220	240	249	271	288
MEDIUM SINGLE	12	16	0	0	0	0	0	0	0	0	0
PISTON	340	355	359	364	370	375	380	385	390	395	400
TOTAL CIVIL	1699	1851	1952	2094	2221	2369	2486	2630	2725	2863	2995

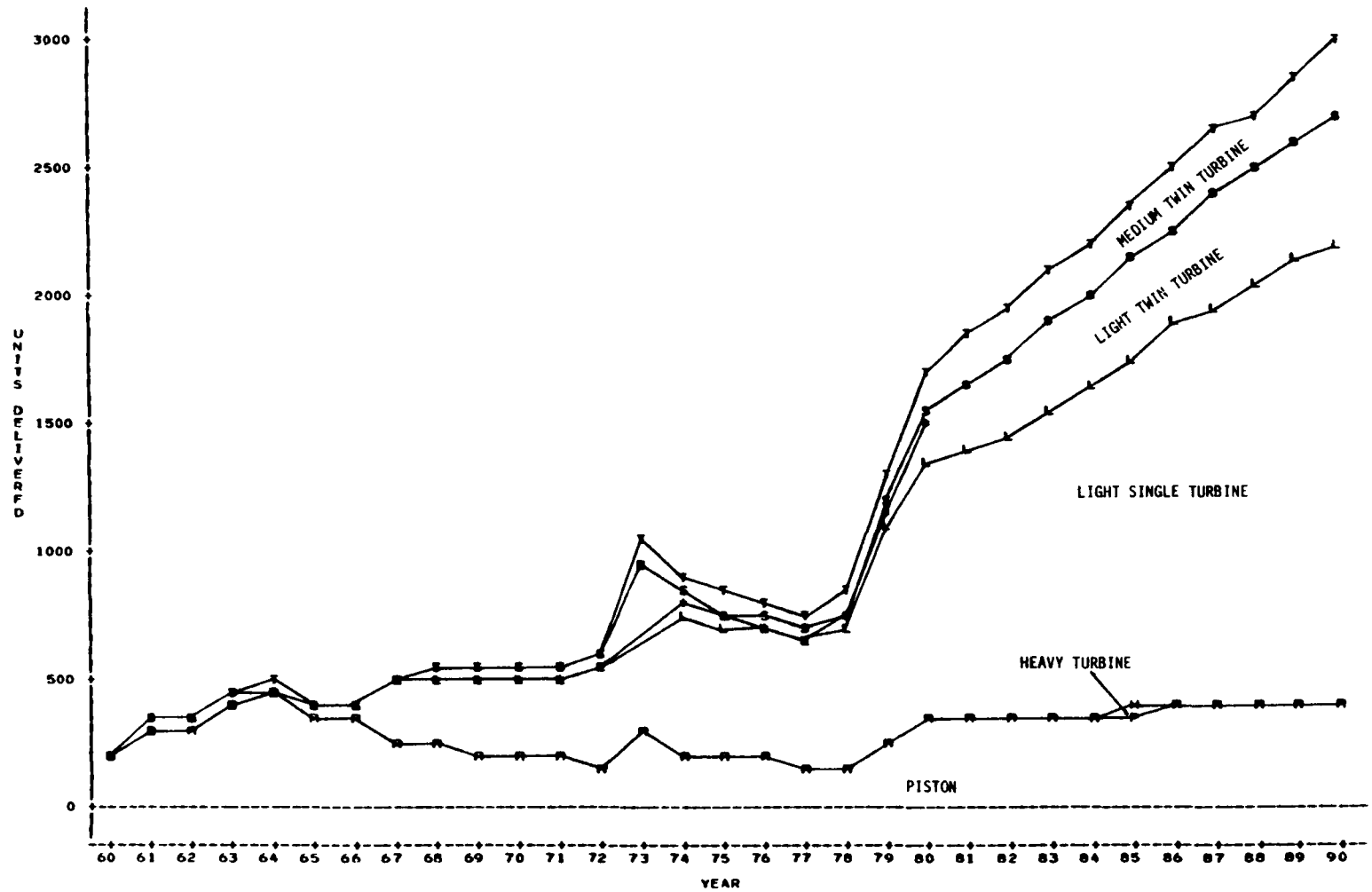

Figure 1.3(a). - Civil Rotorcraft market (units).

TABLE 1.3(b). - CIVIL ROTORCRAFT MARKET ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
HEAVY MULTI	0	0	2	1	0	3	0	0	1	1	0
LIGHT SINGLE	0	1	2	7	7	8	7	29	33	36	41
LIGHT TWIN	0	0	0	0	0	0	0	0	0	0	0
MEDIUM SINGLE	1	2	6	9	5	3	4	9	13	19	17
MEDIUM TWIN	0	0	3	2	4	8	0	4	19	25	6
PISTON	13	17	16	17	20	18	18	12	12	11	10
TOTAL CIVIL	15	19	29	36	35	40	35	53	78	92	87

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
HEAVY MULTI	0	0	0	17	8	9	0	0	5	0	0
LIGHT SINGLE	41	47	61	98	94	161	98	118	129	242	313
LIGHT TWIN	0	0	0	8	15	13	10	17	66	62	191
MEDIUM SINGLE	10	10	9	11	15	18	34	14	25	23	16
MEDIUM TWIN	6	21	34	33	95	169	82	126	129	184	254
PISTON	10	9	7	12	10	10	15	13	12	25	35
TOTAL CIVIL	67	86	111	179	233	269	239	288	365	550	809

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
HEAVY MULTI	0	10	32	43	84	91	98	106	114	123	133
LIGHT SINGLE	313	356	401	469	549	639	741	849	946	1076	1218
LIGHT TWIN	191	261	344	432	515	606	662	763	866	986	1126
MEDIUM SINGLE	16	21	0	0	0	0	0	0	0	0	0
MEDIUM TWIN	254	361	501	568	595	678	774	954	1102	1348	1576
PISTON	35	34	43	47	52	57	62	68	75	82	96
TOTAL CIVIL	809	1078	1321	1559	1795	2071	2337	2740	3103	3615	4143

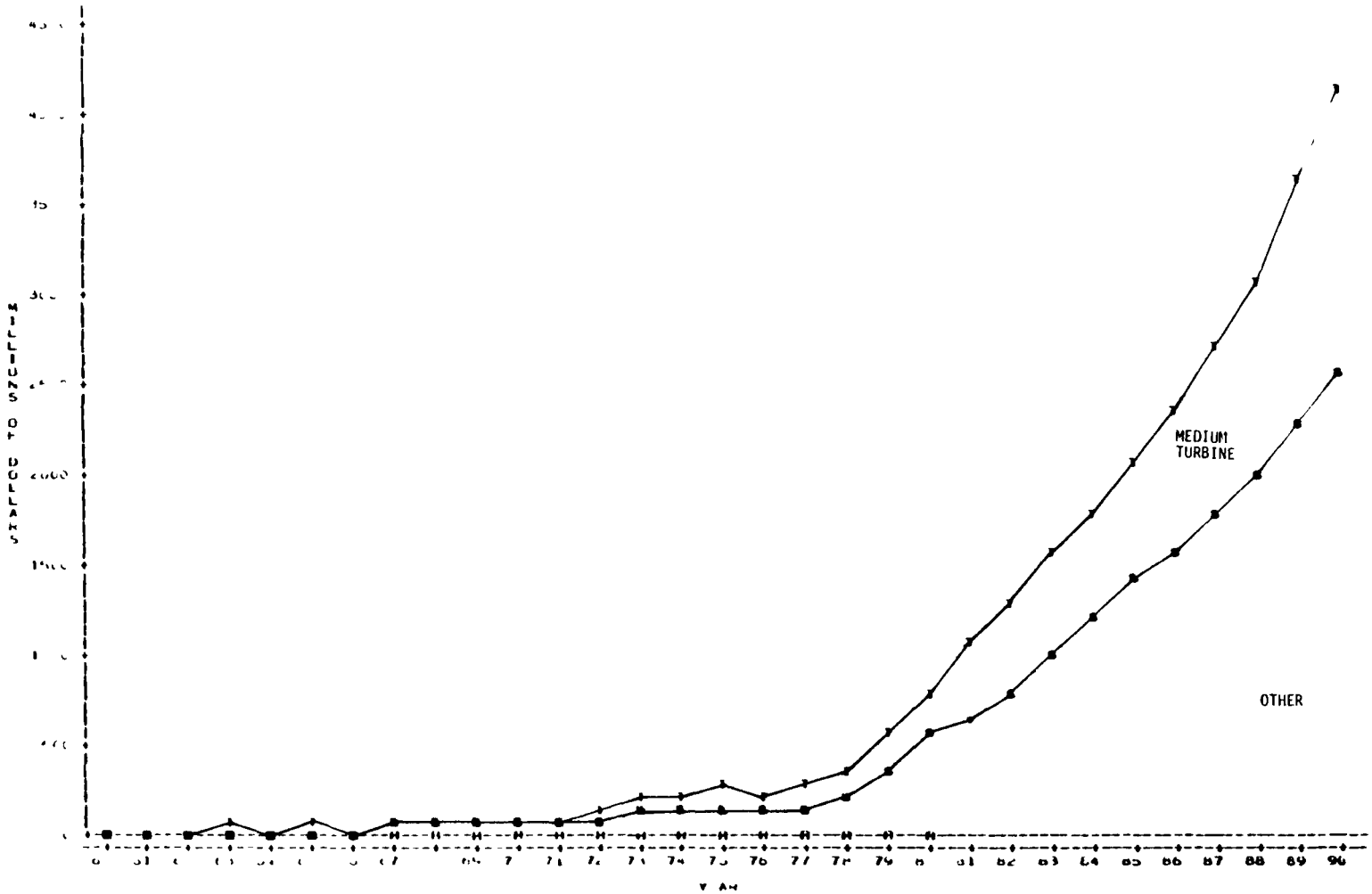

Figure 1.3(b). - Civil rotorcraft market ($ millions).

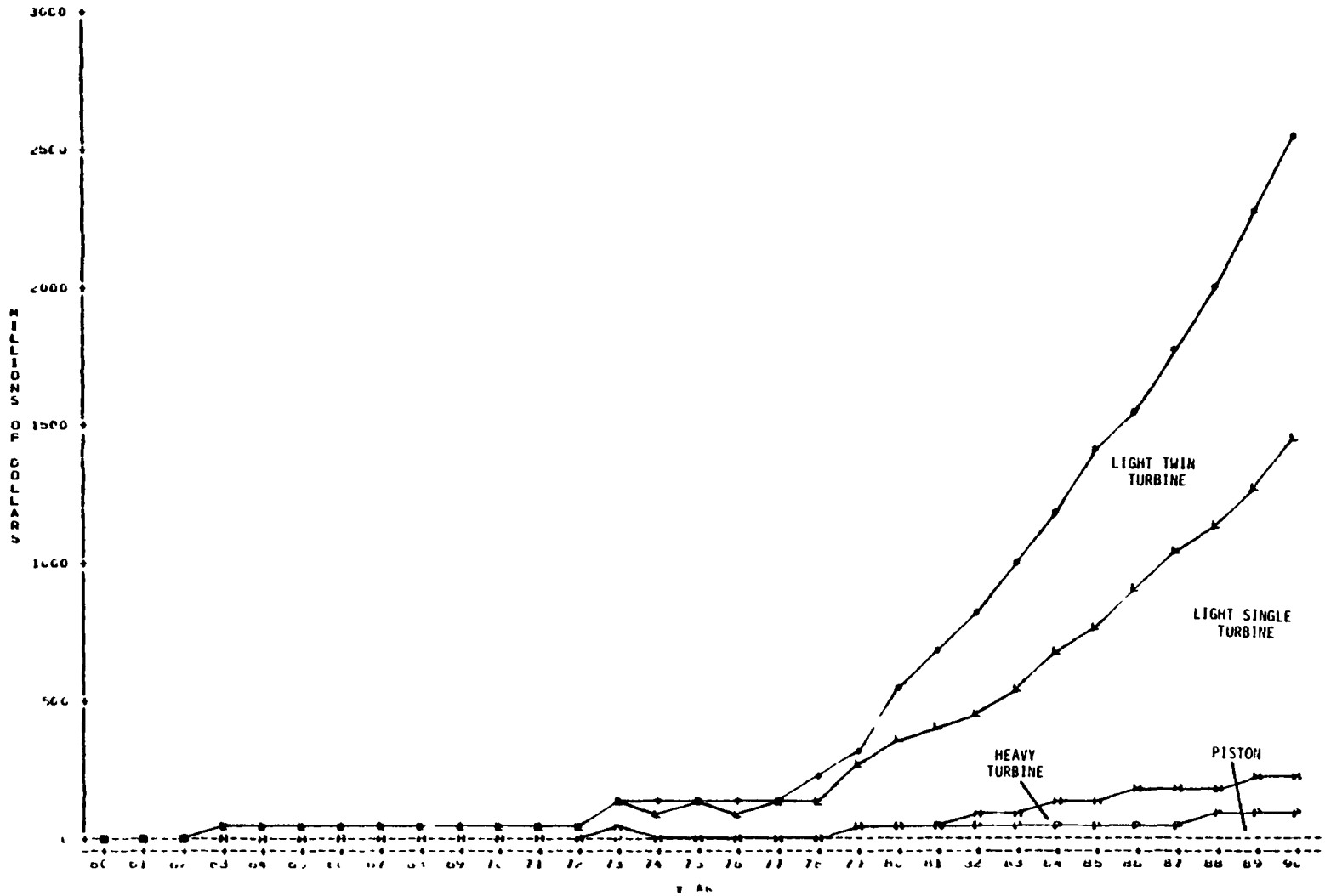

Figure 1.3(b 1). - Other civil rotorcraft market ($ millions).

Free World Military Rotorcraft Market (Tables/Figures 1.3 c & d) - Between 1960 and 1968 the military market more than tripled in unit sales, primarily due to the activation of air mobile units for the Vietnam War. Medium single turbines (Bell UH-1's), light single turbines (Bell OH-58's and Hughes OH-6's) and heavy multi turbines (Boeing/Vertol CH-47's) were the primary ingredients. By 1974/1975 sales had dropped to approximately 1000 units per year, the 1960/1962 level. Since then and until 1990 sales are forecast to fluctuate between 600 and 1000 units per year.

Since 1970, medium turbines have been gradually increasing their share, twin turbines taking over from single turbines as forces modernize and seek a second generation helicopter more suitable for night and inclement weather flight. Similarly, the light twin turbine is forecast to gradually takeover from the single turbines. The high cost of heavy turbines will keep their quantities low for the forecast period. Piston helicopters essentially were phased out by 1970.

The sharp increase in dollar expenditures in medium helicopters in the mid-1980's (Figure 1.3(d 1)) reflects the very high cost of the LAMPS system on the UH-60. The similar increase in armed helicopters (Figure 1.3(d 2)) reflects the high cost of the AH-64.

TABLE 1.3(c). - FREE WORLD MILITARY ROTORCRAFT MARKET (UNITS)

	60	61	62	63	64	65	66	67	68	69	70
HISTORY											
ARMED	0	0	0	0	0	0	0	92	439	248	93
HEAVY MULTI	13	9	11	64	104	172	297	352	410	268	307
LIGHT SINGLE	387	269	479	591	557	529	919	803	631	693	989
LT/MED TWIN	0	0	0	0	0	0	0	0	0	0	0
MEDIUM MULTI	37	68	112	120	156	142	104	85	80	38	125
MEDIUM SINGLE	0	1	9	43	154	414	919	1385	1076	1258	1019
PISTON	533	413	538	602	547	562	493	345	460	65	79
TOTAL MILITARY	970	760	1149	1320	1558	1819	2732	3082	3097	2620	2612

	70	71	72	73	74	75	76	77	78	79	80
HISTORY											
ARMED	93	39	170	44	32	96	68	77	114	127	79
HEAVY MULTI	307	122	40	110	140	90	95	61	34	54	32
LIGHT SINGLE	989	778	752	702	342	285	469	274	244	167	144
LT/MED TWIN	0	4	0	19	7	29	25	22	93	96	111
MEDIUM MULTI	125	271	139	116	114	186	166	118	150	130	229
MEDIUM SINGLE	1019	576	459	316	277	374	278	259	100	76	76
PISTON	79	18	24	56	14	3	0	11	45	0	0
TOTAL MILITARY	2612	1808	1584	1363	926	1063	901	822	780	650	671

	80	81	82	83	84	85	86	87	88	89	90
FORECAST											
ARMED	79	21	41	38	74	212	214	212	214	136	88
HEAVY MULTI	32	37	14	14	14	14	11	11	11	10	8
LIGHT SINGLE	144	145	164	138	127	176	169	111	112	139	110
LT/MED TWIN	111	185	185	163	156	132	87	91	90	97	101
MEDIUM MULTI	229	246	265	294	337	405	427	457	504	577	540
MEDIUM SINGLE	76	16	10	10	10	10	10	10	10	10	10
PISTON	0	0	0	0	0	0	0	0	0	0	0
TOTAL MILITARY	671	650	679	657	718	921	918	892	941	969	857

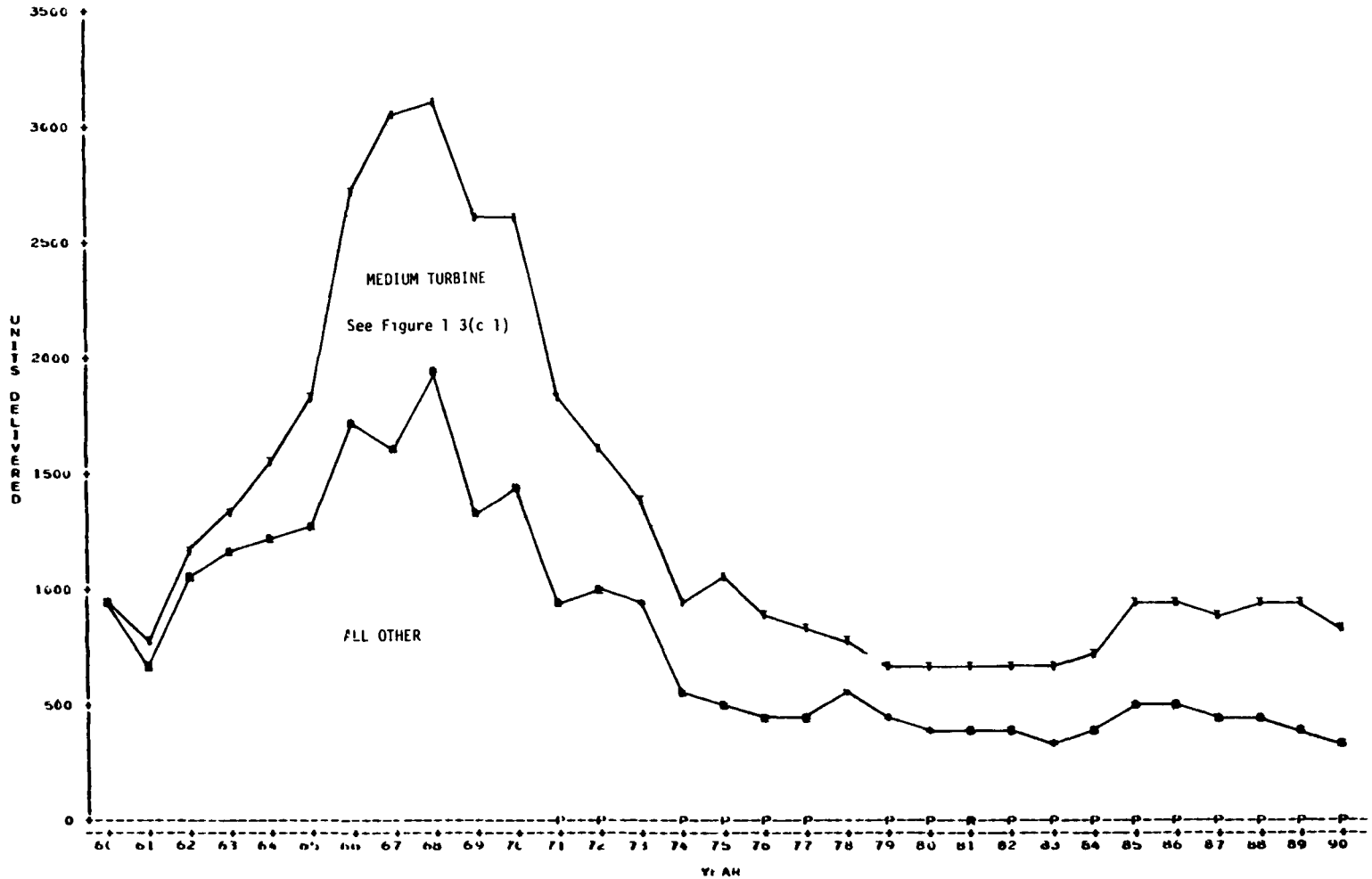

Figure 1.3(c). - Free world military rotorcraft market (units).

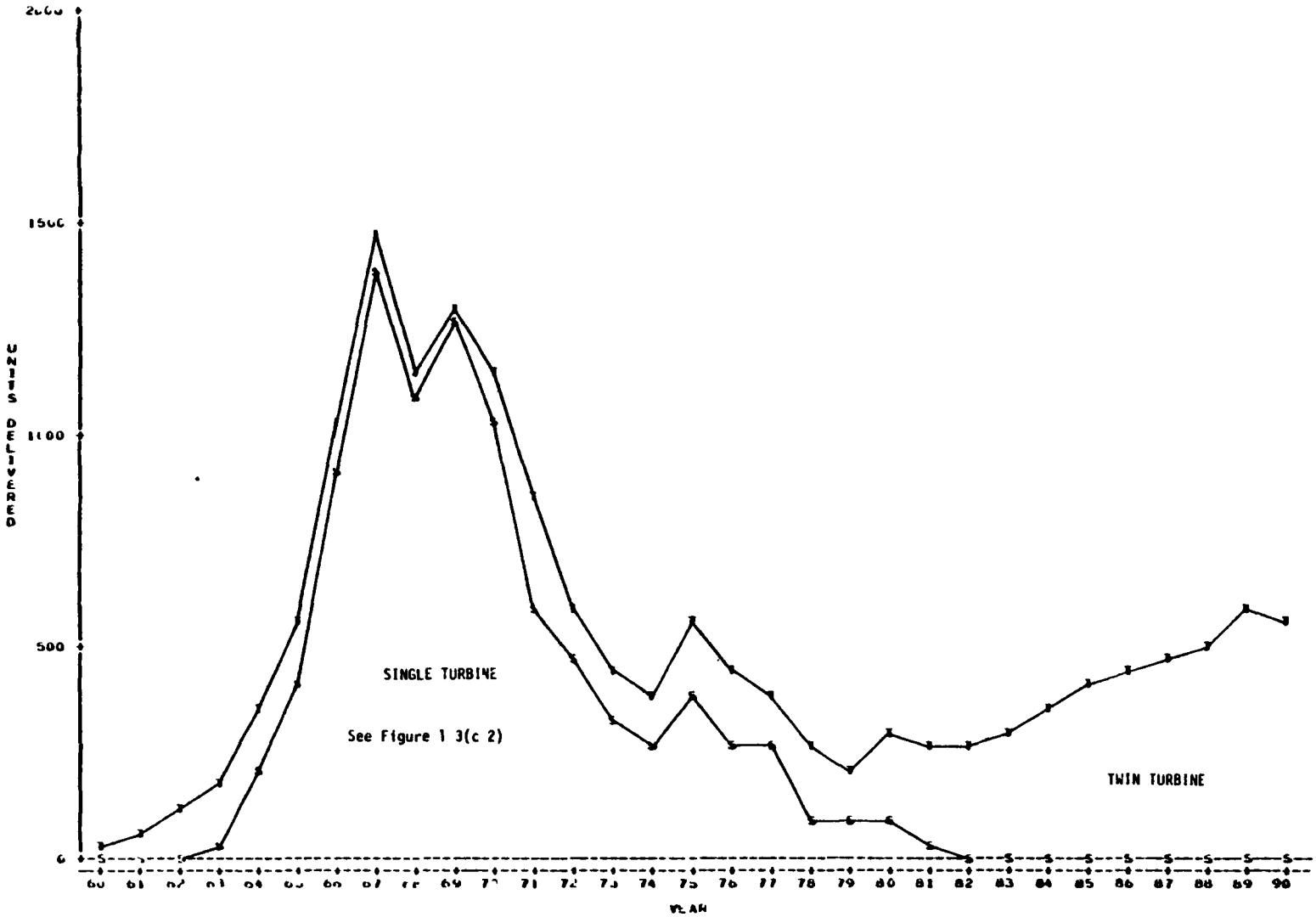

Figure 1.3(c 1). - Free world medium military rotorcraft market (units).

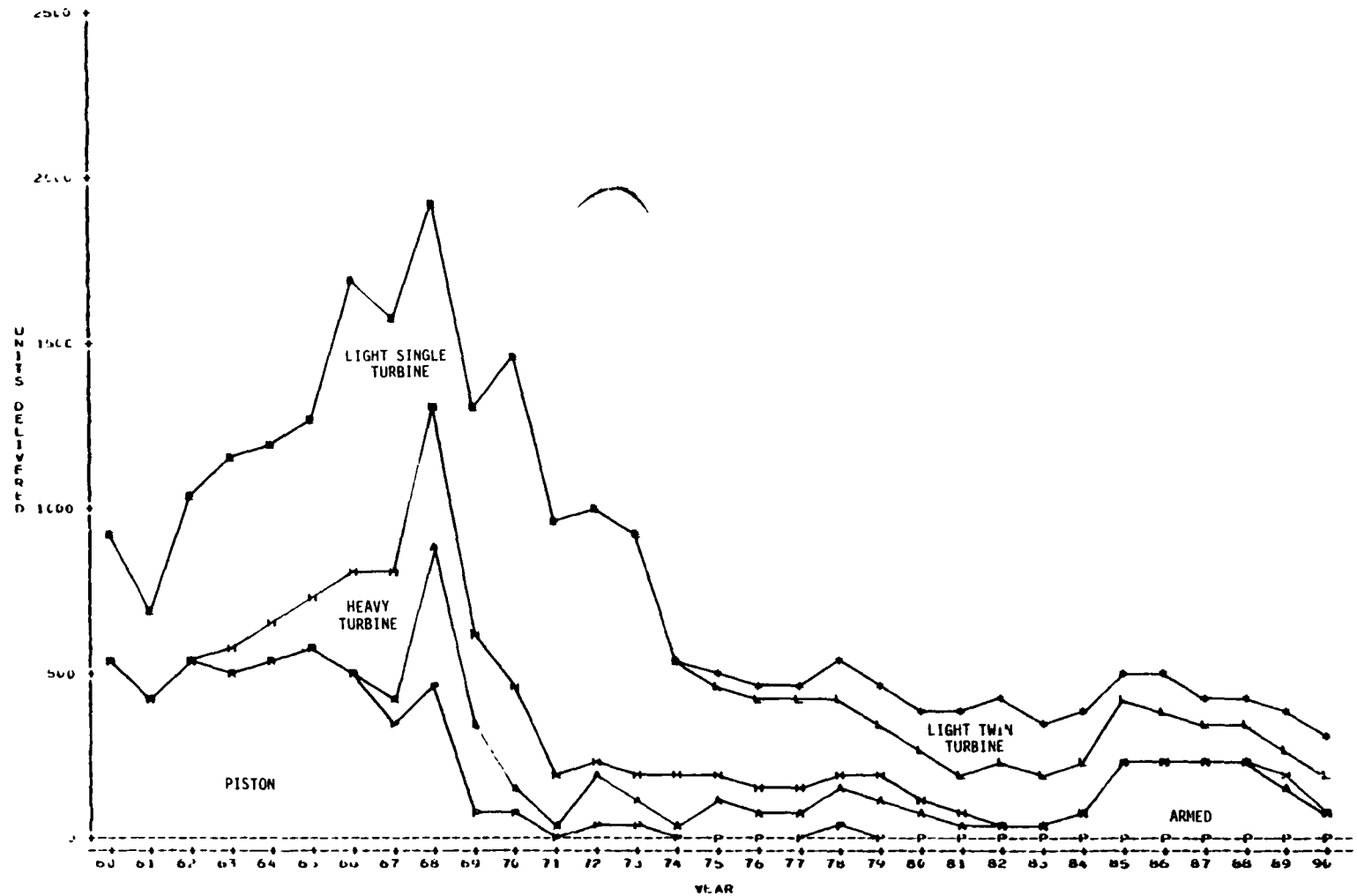

Figure 1.3(c 2). - Free world other military rotorcraft market (units).

TABLE 1.3(d). - FREE WORLD MILITARY ROTORCRAFT MARKET ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
ARMED	0	0	0	0	0	0	0	40	202	144	34
HEAVY MULTI	61	46	14	72	141	256	428	570	695	545	601
LIGHT SINGLE	76	54	90	127	131	122	193	165	110	110	176
LIGHT TWIN	0	0	0	0	0	0	0	0	0	0	0
MEDIUM SINGLE	0	0	1	10	43	92	211	327	541	674	617
MEDIUM TWIN	6	52	89	91	121	119	96	85	85	42	123
PISTON	65	54	67	74	36	33	44	21	25	3	7
TOTAL MILITARY	207	207	261	374	472	621	973	1209	1848	1518	1583

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
ARMED	59	22	94	26	32	106	74	87	145	398	160
HEAVY MULTI	601	254	118	327	356	307	292	248	122	193	190
LIGHT SINGLE	176	126	121	125	73	73	61	80	71	56	48
LIGHT TWIN	0	0	0	5	7	11	10	39	336	407	279
MEDIUM SINGLE	617	365	296	212	204	318	269	271	106	87	83
MEDIUM TWIN	123	241	151	136	154	261	273	212	286	317	556
PISTON	7	1	1	13	1	0	0	0	3	0	0
TOTAL MILITARY	1583	1009	761	844	827	1076	1016	937	1068	1458	1250

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
ARMED	110	29	67	76	305	948	1658	1162	1221	1114	451
HEAVY MULTI	196	236	118	128	138	149	170	163	198	191	156
LIGHT SINGLE	46	52	66	63	59	94	91	61	66	76	76
LIGHT TWIN	279	397	426	352	353	251	225	252	191	222	251
MEDIUM SINGLE	83	13	11	12	13	14	15	16	17	19	20
MEDIUM TWIN	350	616	880	1317	2168	2660	3264	3488	4072	4906	5132
PISTON	0	0	0	0	0	0	0	0	0	0	0
TOTAL MILITARY	1256	1546	1568	1948	2976	4116	4703	5162	5765	6586	6686

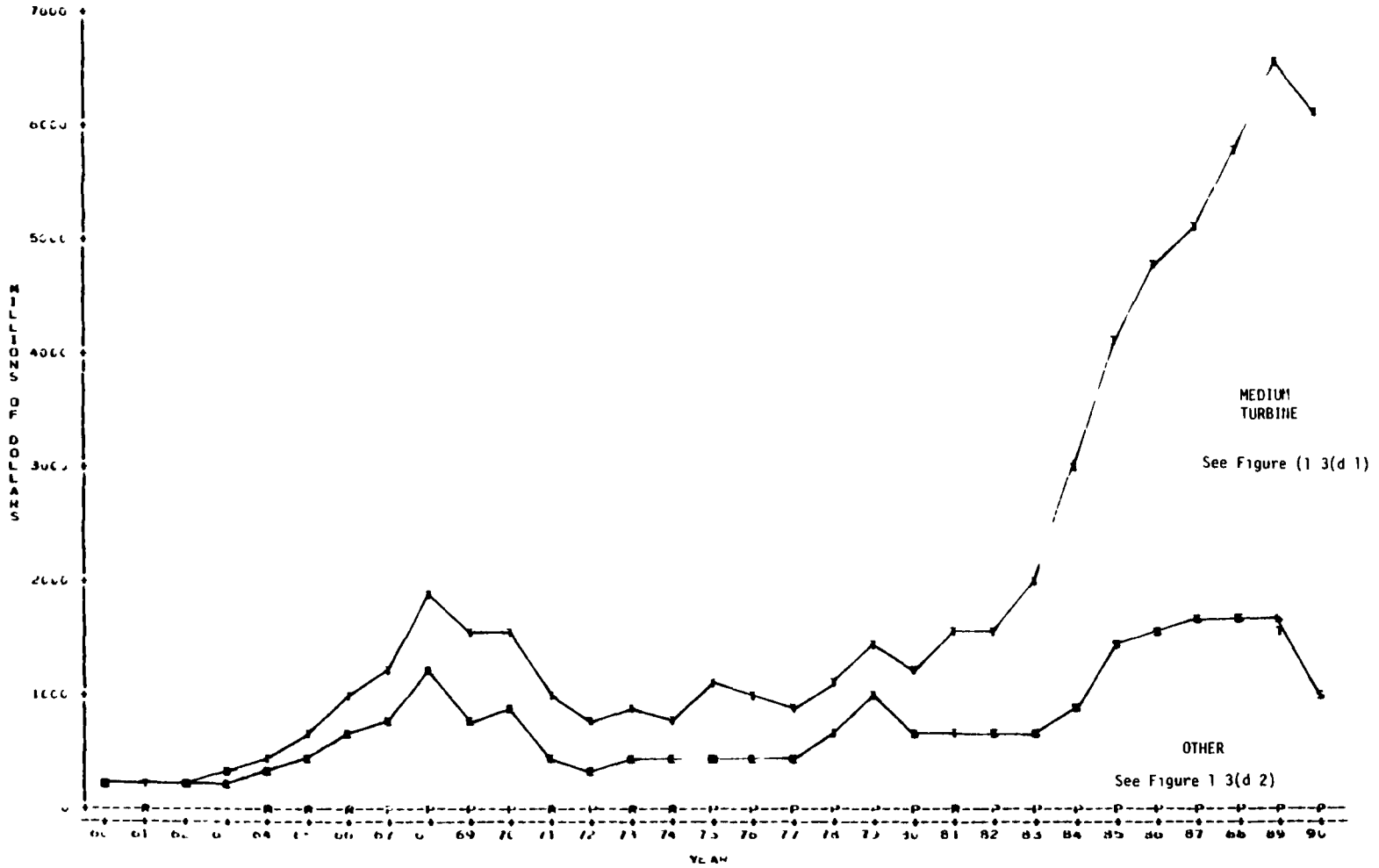

Figure 1.3(d). - Free world military rotorcraft market ($ millions).

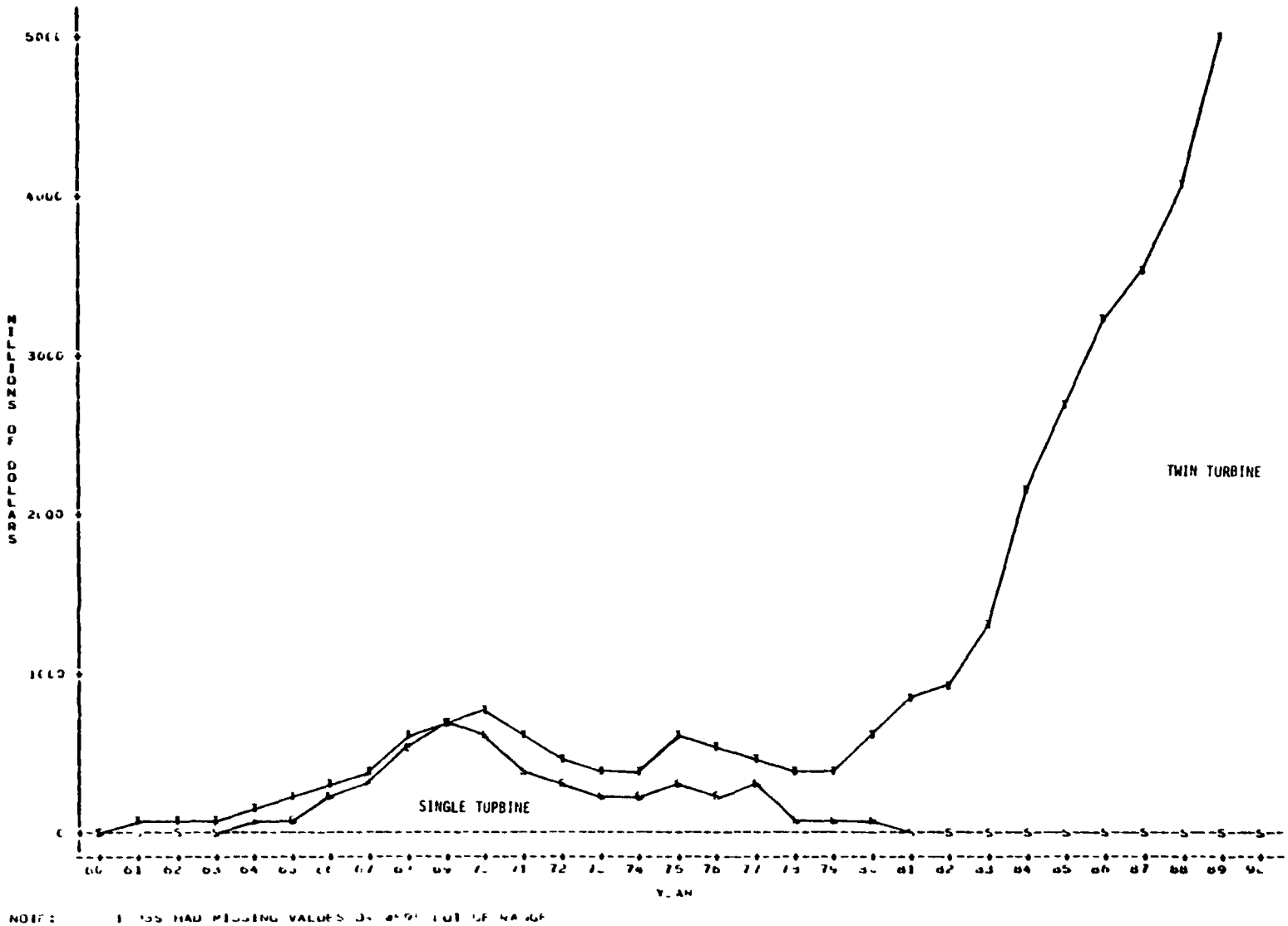

Figure 1.3(d 1). - Free world medium turbine military rotorcraft market ($ millions).

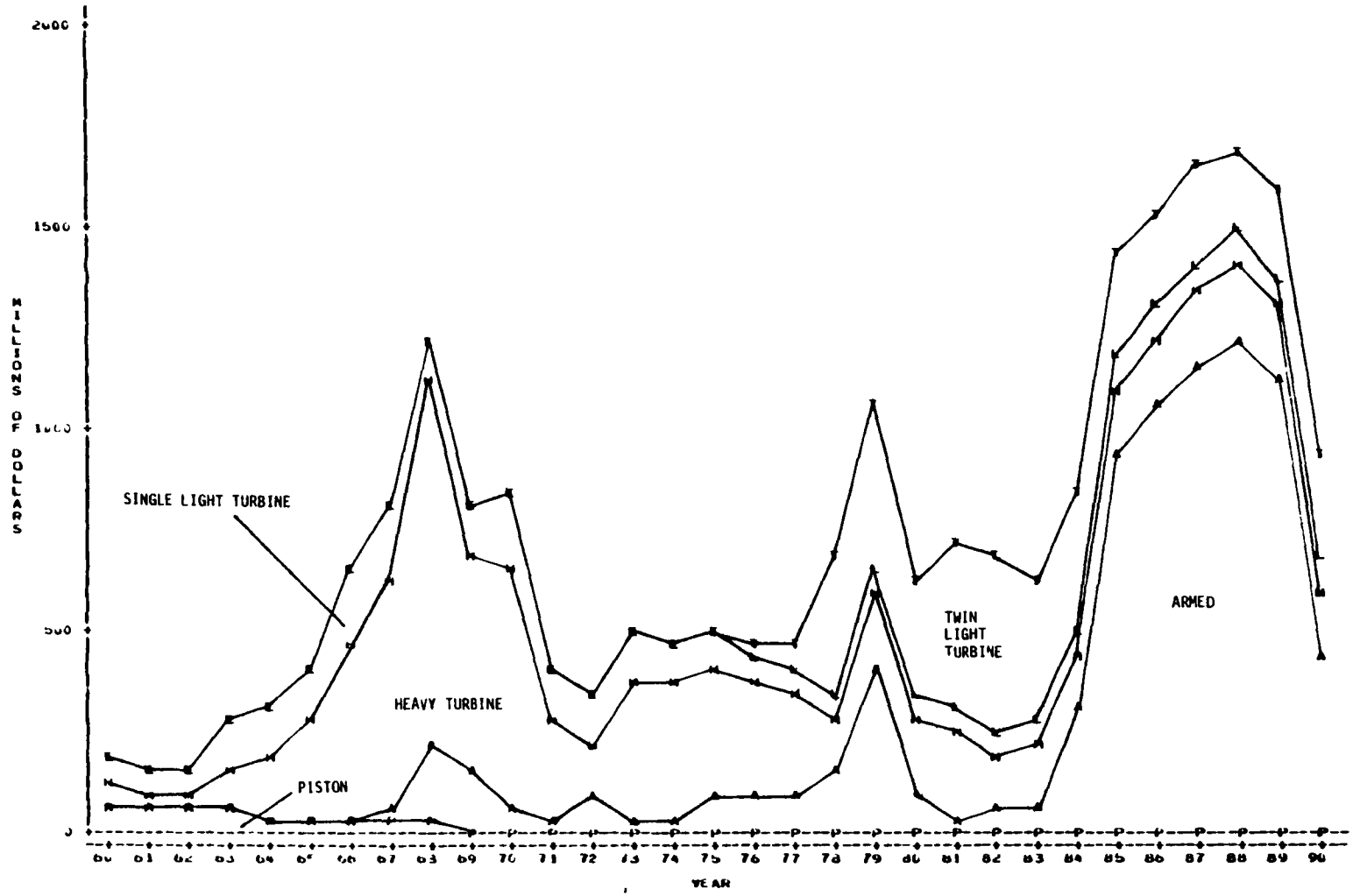

Figure 1.3(d 2). - Free world other military rotorcraft market ($ millions).

Task 1.4 - Documentation of market consumption and growth for civil rotorcraft by the following mission types:

Resource Exploration/Management
Public Service (Fire/police/rescue/ambulance/public health)
Construction
Air Transportation (corporate/air taxi/scheduled/private)
Forestry
Agriculture
Cargo Distribution
Other

Rotorcraft Market by Mission. (Tables/Figures 1.4 a, b, c & d). Resource exploration/management is a major user of helicopters. Support of offshore petroleum exploration and development is by far the major user, followed by onshore exploration and mining.

Offshore drilling was started in the Gulf of Mexico in 1947. By 1948 helicopters were supporting the operation and have been an integral part of petroleum exploration ever since.

Today the helicopter is widely used in international offshore operations, moving drilling crews, technicians, support personnel and critical equipment to and from mobile drilling rigs and production platforms. In addition,they move construction crews to and from production platforms during the construction phase and maintenance personnel during the operating phase. They support pipe-lay barges, diving vessels, and relay pumping platforms. In high density areas such as the North Sea and Mexico, they live offshore furnishing inter-rig shuttles from living quarters vessels to construction sites. Increasingly, they are on standby for rescue operations.

The operating oil companies, who are the customers, are moving farther and farther offshore, demanding longer range and higher speed helicopters. The oil industry has expanded so quickly that skills are in very high demand, putting a premium on safety and comfort so that the skills can be retained. In certain areas, notably northern Scotland, external noise of the helicopter irritates the local inhabitants.

Offshore operations, for the most part, are at sea level. Temperatures range from freezing in the North Sea in the winter to 30°C above, an International Standard Day in the Arabian Gulf. Elsewhere, temperatures average 15°C above standard. Helicopters with surplus power are favored in the warmer climates and are indispensable in the Arabian Gulf.

The tenfold increase in the price of oil over the past decade has set off a worldwide search for oil approaching desperation for some countries. At the same time, the international energy demand has increased from 35 million barrels per day of oil equivalent in 1935 to 60 million barrels per day in 1980. For the future, through the year 2,000, 56 percent of the oil is forecast to come from already discovered but not fully developed sources, 35 percent from oil still to be discovered, and 9 percent from synthetics.

The intensity of the offshore search for oil is illustrated in the Gulf of Mexico. This year, there are 847 helicopters (148 mediums) supporting 137 mobile drilling rigs, 992 multi-well production platforms, and 117 more under construction. There are well over 500 medium helicopters operating offshore worldwide. Steady growth in this market is foreseen.

Onshore, some oil and gas drill rigs have been designated to breakdown into loads that can be lifted by helicopters. They are used extensively in the Rocky Mountains, the Amazon Basin, and the islands of Indonesia. Their use is expected to increase as exploration extends into the overthrust belts of the Andes and the Himalayas, as is now occurring in the Rockies.

In mining, helicopters are used for surveys to lift coreing drills and to move supervisory personnel, technicians and critical equipment to and from the mines. This market is expected to expand with the worldwide search for coal as a substitute for oil.

Helicopters are used in public service in a variety of ways. In the U.S., they are used primarily by the Coast Guard for rescue and offshore security patrol, by city and state police, and by city fire departments. In other countries, they are used much more broadly and can be found in National police forces and many of the ministry and agencies such as agriculture, public works, electric commission, rural credit bank, land planning, communications, commission for popular subsistence, water resources, social security, commerce, attorney general, nuclear energy, natural resources, public health, governors and mayors.

In the U.S., the public service market was only 4 units in 1960, growing to 40 by 1970, falling off slightly by 1980. By 1990, it is forecast to increase to more than 60 units per year as demand for aerial ambulances increases. (See Tables/ Figures 1.4a & b).

The free world market, starting with the same 4 in 1960, grew to more than 70 by 1970, nearly 170 by 1980 and is forecast to approach 270 units per year by 1990 (See Tables/Figures 1.4c & d).

The mission titled "Other" incorporates a wide variety of sub-missions performed by helicopters, such as powerline patrol, pipeline patrol, media (press/television/etc.), training, surveying and mapping, and a broad category called utility for those helicopter operators that provide a wide range of tasks with the same aircraft. It also includes those helicopters where the mission is unknown.

In the U.S., the market for this mission was about 40 units per year in 1960 substantially increasing in the mid-1960's and then returning nearly to its former level. The real growth occurred in the 1970's, nearly 300 units per year by 1980, and forecast to approach 500 units per year by 1990.

In the free world, the market in the 1960's was approximately 120 units per year, growing to nearly 250 by 1970, approaching 600 in 1980 and forecast to approach 1000 units by 1990.

The mission "Forestry" includes helicopters dedicated to forest management, to include timber cruising, spraying and logging. It does not include fire fighting as that is largely seasonal and utilizes helicopters doing other tasks for the rest of the year.

In the U.S. during the 1960's and 1970's, the market fluctuated between 3 and 14 new units per year, the need being filled to a large extent by used helicopters. In 1979, the market took a strong up turn to 23 new units and the high cost of forest products indicates that the market will grow to more than 40 units per year by 1990 as the productivity contributions of the helicopter are made known to forest managers (see Tables/ Figures 1.4).

The Air Transportation Market is made up, for the most part, of corporate, private and air taxi owners. With the exception of the government subsidized programs in the U.K. (British Airways Helicopters routes to an offshore island and inter-airport shuttle near London), helicopter scheduled air transportation has been notably unsuccessful. Failures have occurred in many communities in recent years, including New York, Chicago, San Francisco and Los Angeles. However attempts will continue until a satisfactory formula is found.

The civil Air Transportation Market in the U.S. has grown tenfold over the past two decades and is expected to increase by 66 percent by 1990. It now holds 33 percent of the total

commercial market in the U.S. and the share is expected to decrease slightly over the next decade. The market has grown even faster in the total free world, increasing thirteenfold over the last two decades and forecast to nearly double by 1990. The share of the civil market is 28 percent and forecast to remain so. The lower share in the free world as opposed to the U.S. reflects a larger foreign civil government share.

Procurement of new helicopters for agriculture has been slow growing in the U.S. because of the operators' practice of keeping used helicopters. Future growth is not expected to be dramatic. Internationally, the growth is somewhat stronger and forecast to continue to grow with the worldwide demand for increased food production. The current market of 64 units per year is expected to double by 1990.

Cargo distribution (characterized by ship-to-shore cargo unloading) has been a very small and sporadic market, only instituted to overcome harbor congestion encountered in ports such as Lagos, Nigeria and Jedda, Saudi Arabia. In both instances, the task was completed in a matter of months.

TABLE 1.4(a). - U. S. CIVIL ROTORCRAFT MARKET BY MISSION (UNITS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
CIVIL											
AGRICULTURE	8	14	21	11	24	13	25	26	15	13	17
AIR TRANSPORT	30	40	38	56	41	45	34	55	87	81	50
CARGO DISTRIB	0	0	0	0	2	0	1	3	2	0	0
CONSTRUCTION	2	3	2	5	5	6	5	9	12	9	15
FORESTRY	4	3	7	4	3	4	12	11	6	9	4
OTHER	39	75	83	143	140	80	117	81	96	67	48
PUBLIC SRVICE	4	2	4	4	5	5	6	12	26	37	40
RESOURCE EXPL	9	6	9	6	9	12	28	39	38	30	36
TOTAL CIVIL	96	143	164	229	229	165	228	236	282	246	210
TOTAL UNITED STATES	96	143	164	229	229	165	228	236	282	246	210

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
CIVIL											
AGRICULTURE	17	7	9	20	24	24	27	17	14	27	28
AIR TRANSPORT	50	61	59	173	139	100	140	114	101	283	301
CARGO DISTRIB	0	3	1	6	1	0	0	1	0	1	0
CONSTRUCTION	15	12	20	29	39	19	20	13	19	26	27
FORESTRY	4	4	9	11	14	8	14	8	6	23	25
OTHER	48	47	79	217	153	146	99	97	129	278	291
PUBLIC SRVICE	40	49	39	52	37	18	19	17	14	34	34
RESOURCE EXPL	36	33	48	51	83	111	76	84	110	166	181
TOTAL CIVIL	210	216	264	559	490	426	405	351	393	838	887
TOTAL UNITED STATES	210	216	264	559	490	426	405	351	393	838	887

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
CIVIL											
AGRICULTURE	28	28	31	33	35	37	39	41	43	45	47
AIR TRANSPORT	301	308	331	347	367	396	413	436	454	476	496
CARGO DISTRIB	0	0	0	0	0	0	0	0	0	0	0
CONSTRUCTION	27	27	30	32	34	36	38	40	42	44	46
FORESTRY	25	25	28	29	31	34	36	38	39	41	43
OTHER	291	297	320	336	357	383	402	425	443	463	484
PUBLIC SRVICE	34	34	38	41	44	48	52	55	59	62	66
RESOURCE EXPL	181	191	213	230	251	276	297	320	340	362	385
TOTAL CIVIL	887	910	991	1048	1119	1210	1277	1355	1420	1493	1567
TOTAL UNITED STATES	887	910	991	1048	1119	1210	1277	1355	1420	1493	1567

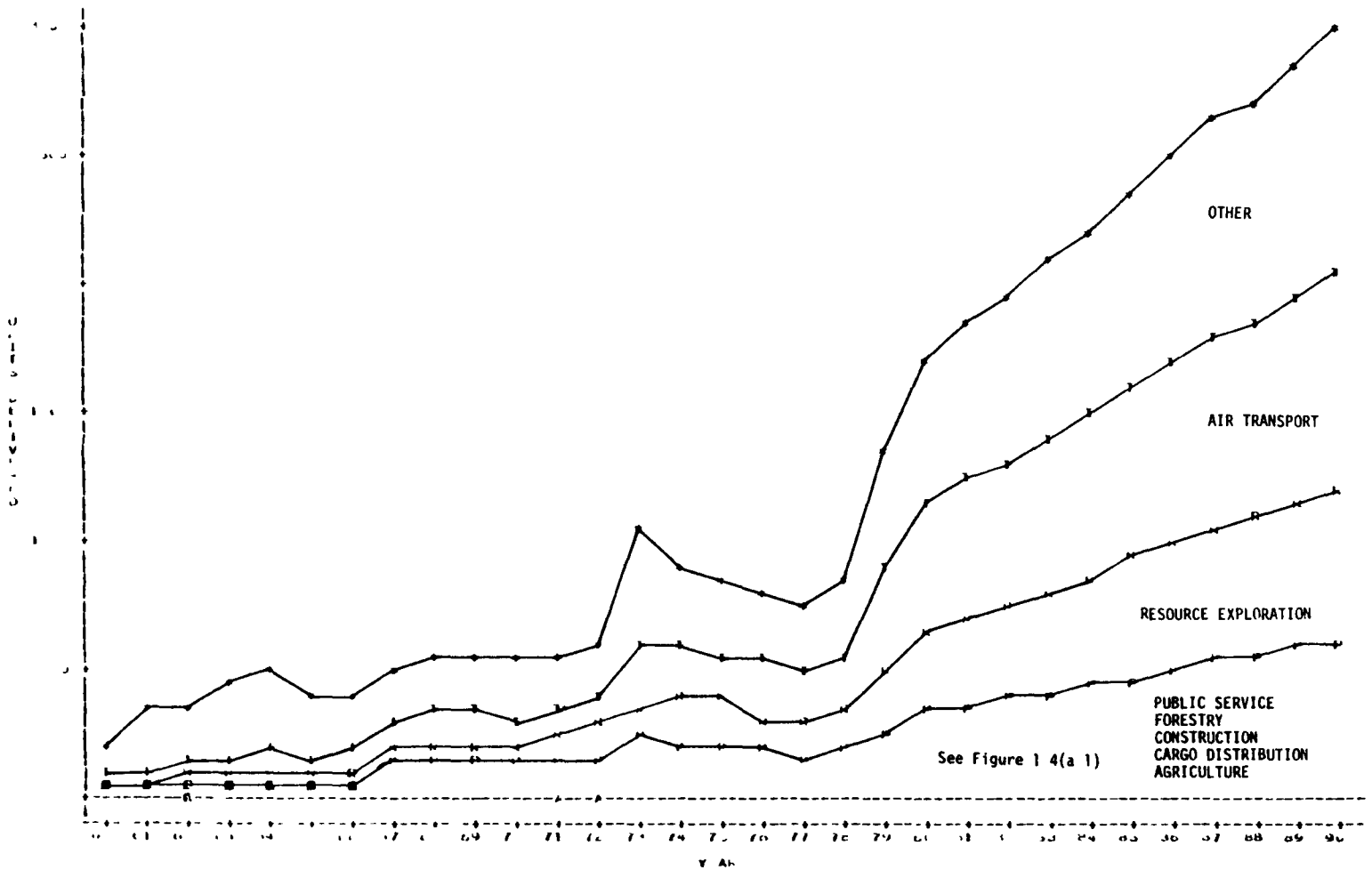

Figure 1.4(a). - U. S. civil rotorcraft market by mission (units).

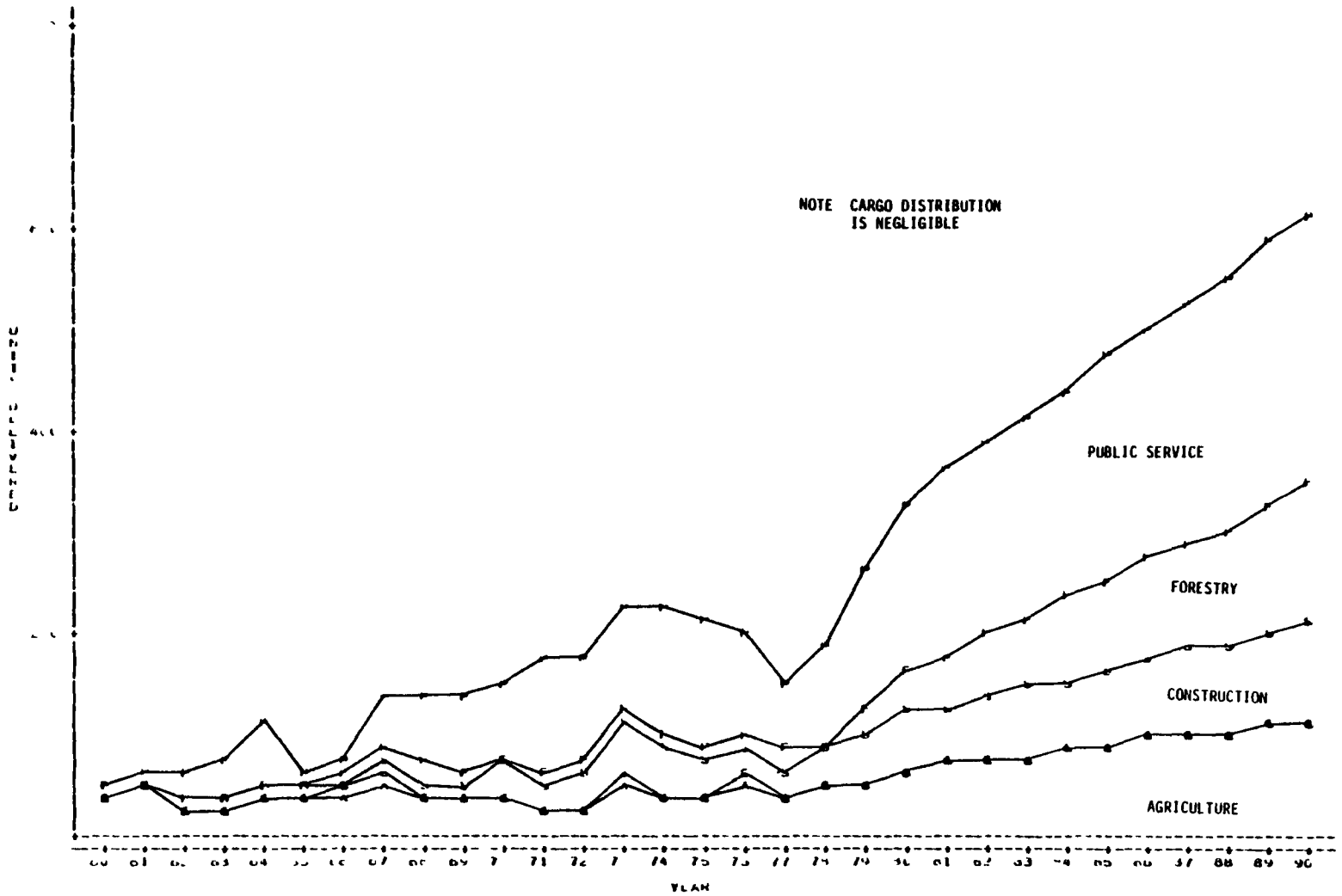

Figure 1.4(a 1). - U. S. civil rotorcraft market by mission (units).

TABLE 1.4(b). - U. S. CIVIL ROTORCRAFT MARKET BY MISSION ($ MILLIONS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
CIVIL											
AGRICULTURE	0	1	1	0	1	1	1	1	1	1	1
AIR TRANSPORT	3	2	6	3	3	5	2	5	9	12	6
CARGO DISTRIB	0	0	0	0	0	0	0	0	0	0	0
CONSTRUCTION	0	0	1	1	0	0	0	1	1	1	2
FORESTRY	0	0	0	0	0	0	1	2	1	1	1
OTHER	2	4	7	13	8	5	10	10	25	19	7
PUBLIC SRVICE	0	0	0	0	0	0	0	1	2	3	3
RESOURCE EXPL	1	1	0	1	1	4	3	5	7	5	5
TOTAL CIVIL	7	8	15	18	14	16	18	24	46	42	24
TOTAL UNITED STATES	7	8	15	18	14	16	18	24	46	42	24

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
CIVIL											
AGRICULTURE	1	1	1	2	2	5	2	3	3	6	13
AIR TRANSPORT	6	9	7	18	22	20	45	30	27	77	137
CARGO DISTRIB	0	0	0	15	0	0	0	0	0	0	0
CONSTRUCTION	2	2	4	5	12	4	3	5	5	8	12
FORESTRY	1	0	1	2	3	11	6	3	2	9	11
OTHER	7	4	11	28	24	25	16	22	36	79	129
PUBLIC SRVICE	3	3	3	7	5	3	4	5	4	7	15
RESOURCE EXPL	5	6	8	15	24	37	25	40	44	84	82
TOTAL CIVIL	24	27	36	92	94	105	100	107	121	270	399
TOTAL UNITED STATES	24	27	36	92	94	105	100	107	121	270	399

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
CIVIL											
AGRICULTURE	13	18	22	26	27	31	35	41	46	54	61
AIR TRANSPORT	137	194	238	270	286	331	367	439	483	567	643
CARGO DISTRIB	0	0	0	0	0	0	0	0	0	0	0
CONSTRUCTION	12	17	22	25	27	30	34	40	45	52	60
FORESTRY	11	16	20	23	24	28	32	38	41	49	56
OTHER	129	183	226	255	270	310	347	419	461	540	616
PUBLIC SRVICE	15	21	27	32	34	40	46	55	63	74	86
RESOURCE EXPL	82	120	153	179	196	231	264	323	362	431	499
TOTAL CIVIL	399	569	708	810	864	1001	1125	1355	1501	1767	2021
TOTAL UNITED STATES	399	569	708	810	864	1001	1125	1355	1501	1767	2021

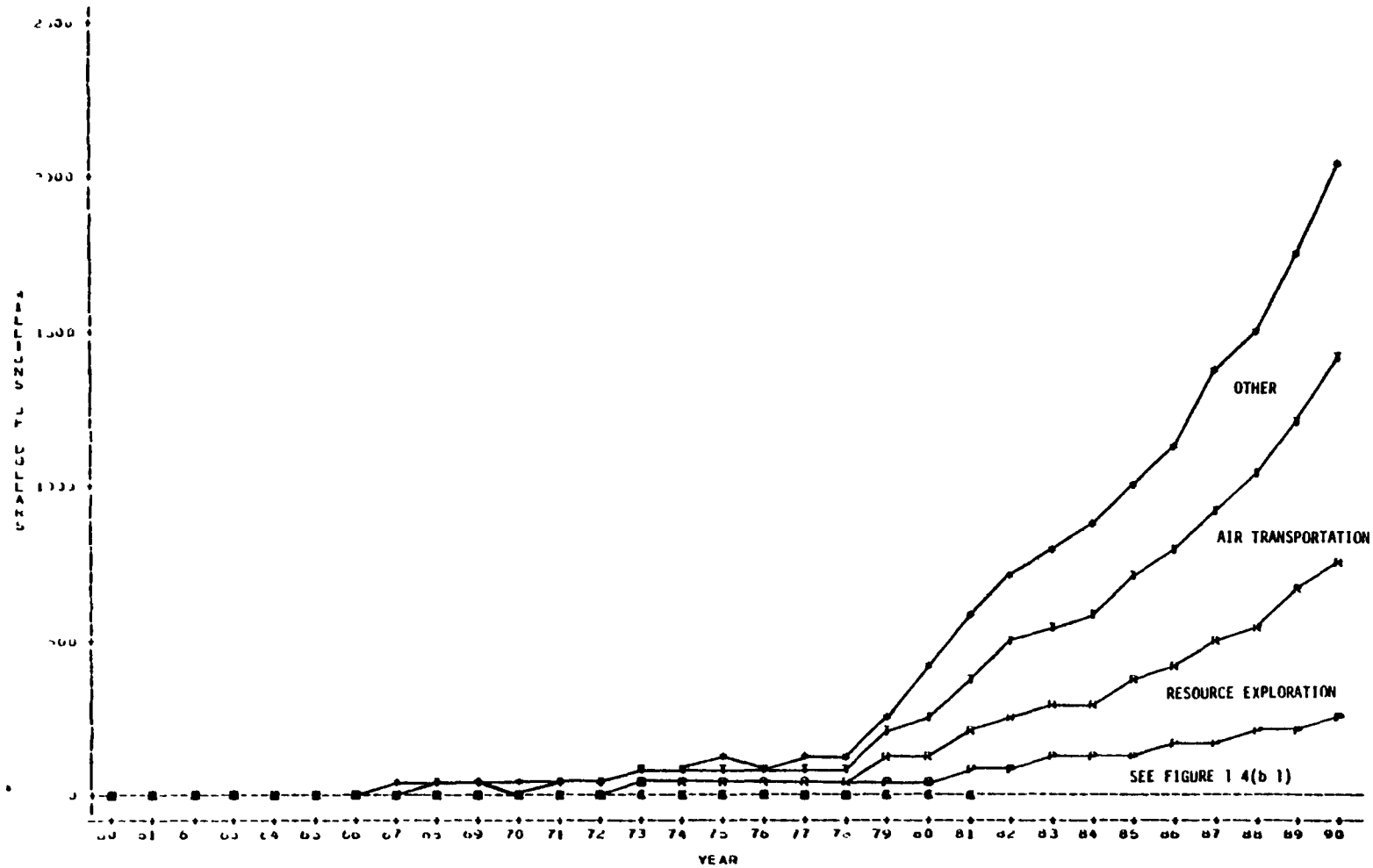

Figure 1.4(b). - U. S. civil rotorcraft market by mission ($ millions).

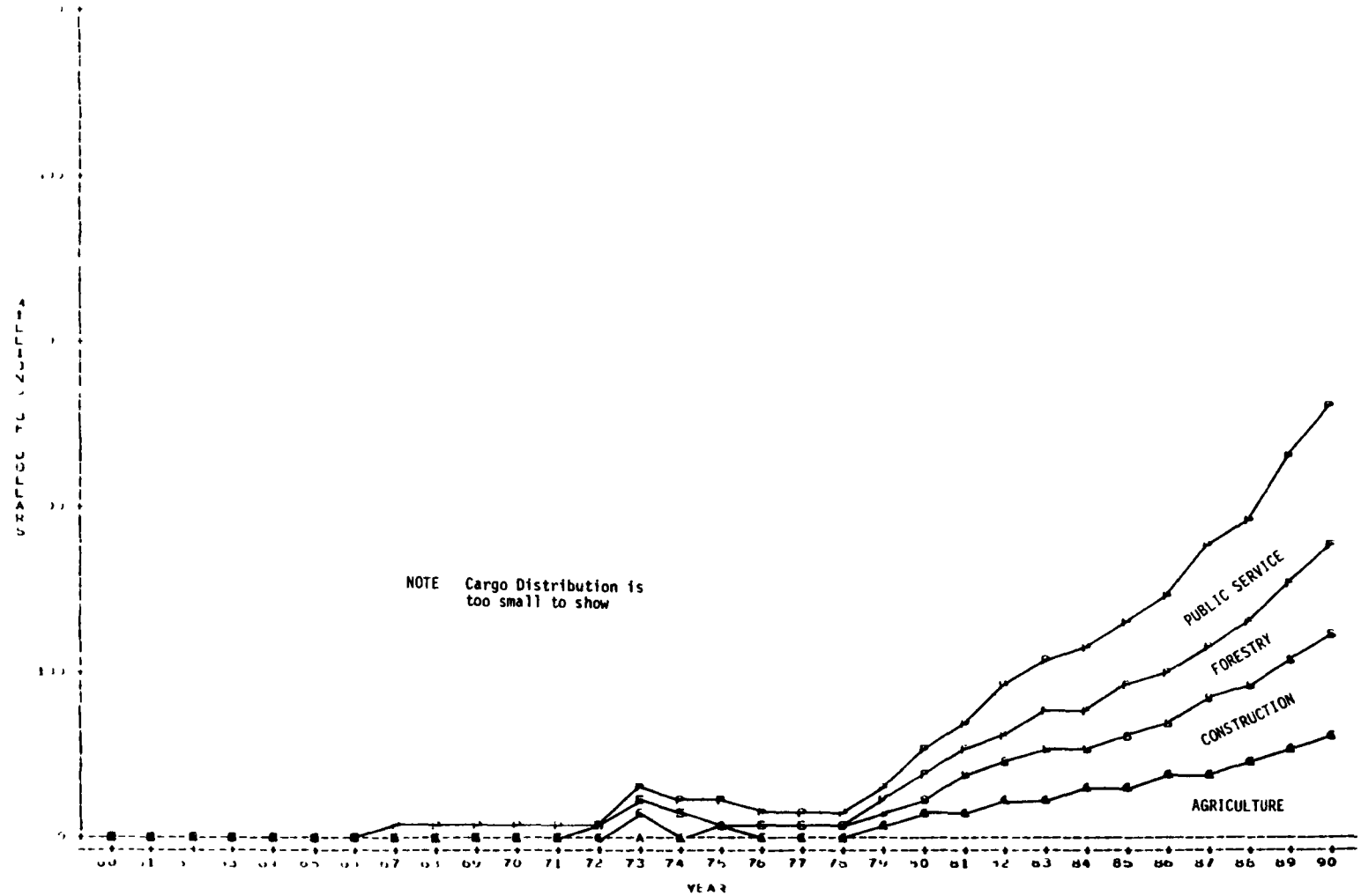

Figure 1.4(b 1). - U. S. civil rotorcraft market by mission ($ millions).

TABLE 1.4(c). - FREE WORLD CIVIL ROTORCRAFT MARKET BY MISSION (UNITS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
CIVIL											
AGRICULTURE	33	45	25	27	36	34	43	53	35	40	41
AIR TRANSPORT	36	53	52	74	53	70	56	97	128	118	84
CARGO DISTRIB	0	0	0	0	2	2	1	8	2	0	2
CONSTRUCTION	9	6	4	5	7	10	9	12	16	14	26
FORESTRY	7	4	11	11	5	7	14	15	17	13	6
OTHER	121	208	231	298	300	260	232	208	227	216	248
PUBLIC SRVICE	4	7	27	31	57	15	11	53	69	74	72
RESOURCE EXPL	12	8	20	14	20	25	47	62	75	74	68
TOTAL CIVIL	222	331	370	450	480	423	413	508	569	549	547

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
CIVIL											
AGRICULTURE	41	23	25	51	32	40	55	42	46	51	64
AIR TRANSPORT	84	93	108	261	204	155	228	206	189	390	476
CARGO DISTRIB	2	3	1	6	2	1	3	1	1	1	0
CONSTRUCTION	26	22	35	52	48	31	30	23	35	45	55
FORESTRY	6	14	12	20	22	16	18	17	11	33	43
OTHER	248	229	233	439	329	314	249	250	303	467	572
PUBLIC SRVICE	72	112	102	101	121	119	91	71	91	132	167
RESOURCE EXPL	68	82	109	110	156	182	129	147	162	231	322
TOTAL CIVIL	547	558	625	1040	914	862	803	757	838	1350	1699

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
CIVIL											
AGRICULTURE	64	70	75	81	86	92	97	103	106	112	118
AIR TRANSPORT	476	520	548	588	623	665	698	738	765	804	841
CARGO DISTRIB	0	0	0	0	0	0	0	0	0	0	0
CONSTRUCTION	55	59	62	66	70	74	78	82	85	89	93
FORESTRY	43	52	60	69	78	88	97	107	115	125	135
OTHER	572	618	647	690	727	772	805	848	875	915	953
PUBLIC SRVICE	167	179	187	198	209	219	228	239	246	256	266
RESOURCE EXPL	322	353	373	402	429	459	483	513	533	562	589
TOTAL CIVIL	1699	1851	1952	2034	2221	2369	2486	2630	2725	2863	2995

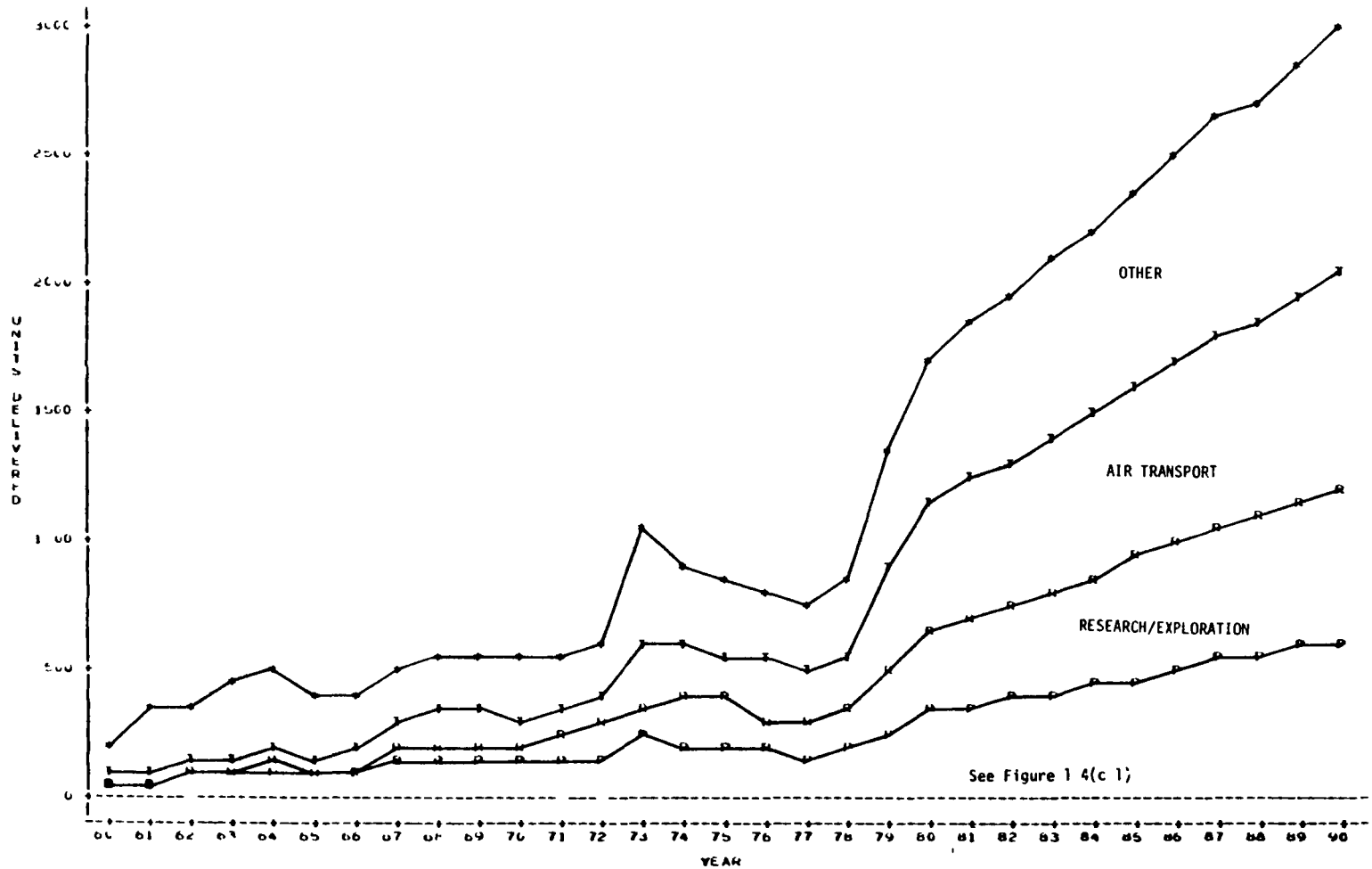

Figure 1.4(c). - Free world civil rotorcraft market by mission (units).

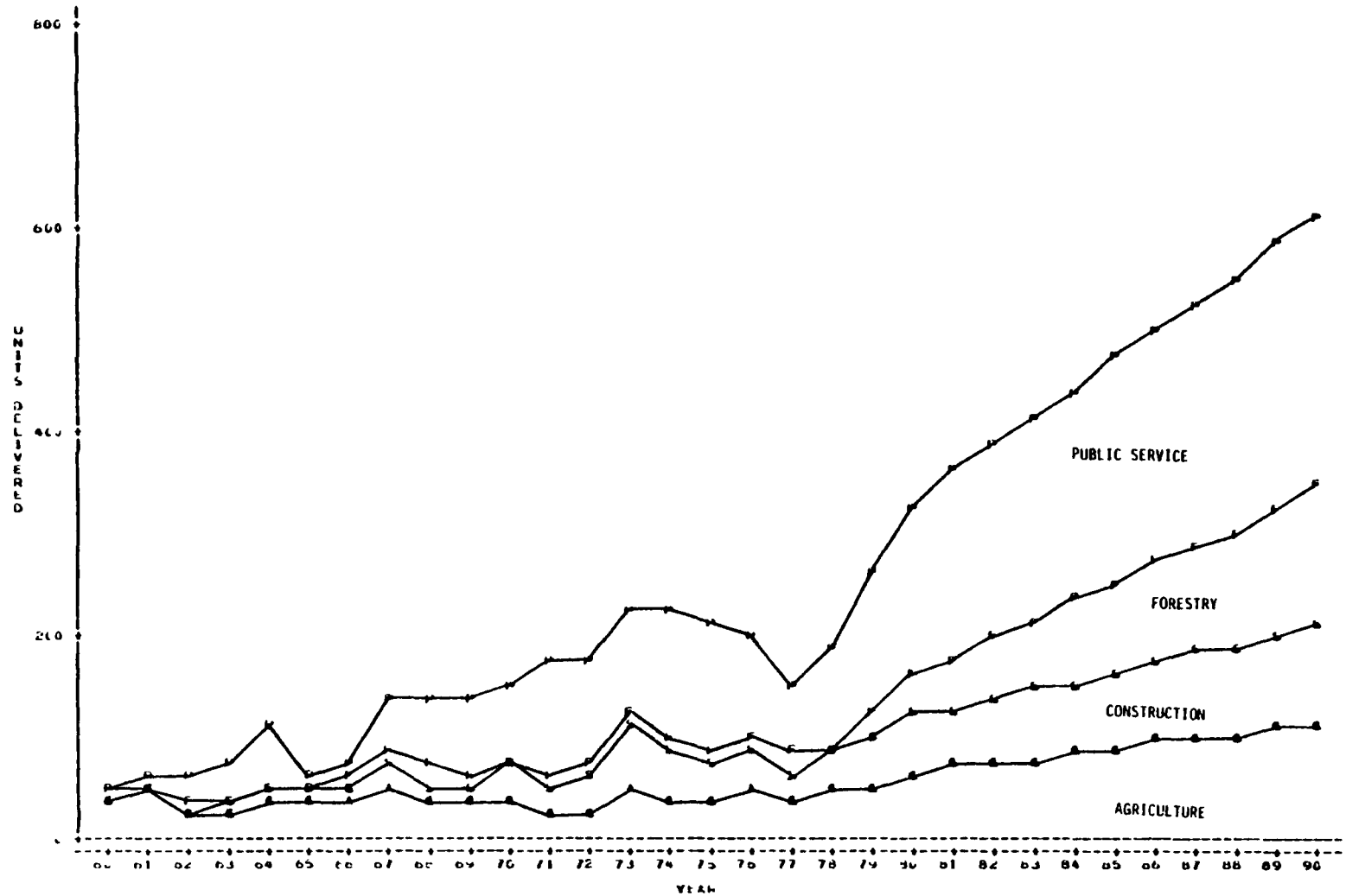

Figure 1.4(c 1). - Free world civil rotorcraft market by mission (units).

TABLE 1.4(d). - FREE WORLD CIVIL ROTORCRAFT MARKET BY MISSION ($ MILLIONS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
CIVIL											
AGRICULTURE	2	2	1	1	2	2	2	3	2	2	3
AIR TRANSPORT	3	3	7	6	5	6	5	9	14	17	9
CARGO DISTRIB	0	0	0	0	0	1	0	1	0	0	0
CONSTRUCTION	1	0	1	1	0	1	1	1	1	2	3
FORESTRY	1	0	0	1	0	0	1	2	2	1	1
OTHER	7	12	15	22	17	21	16	21	38	37	29
PUBLIC SRVICE	0	1	3	3	7	1	1	6	7	13	8
RESOURCE EXPL	2	1	1	3	5	7	9	9	14	20	14
TOTAL CIVIL	15	19	29	36	35	40	35	53	78	93	67

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
CIVIL											
AGRICULTURE	3	3	2	5	4	7	6	6	7	12	32
AIR TRANSPORT	9	15	21	31	35	33	64	56	66	125	239
CARGO DISTRIB	0	0	0	15	1	1	2	0	0	0	0
CONSTRUCTION	3	3	6	9	14	7	8	11	16	16	28
FORESTRY	1	1	1	3	4	12	7	9	3	13	22
OTHER	29	31	35	63	58	69	53	54	98	145	243
PUBLIC SRVICE	8	17	13	30	32	35	36	38	51	59	84
RESOURCE EXPL	14	18	33	43	84	97	64	115	123	167	161
TOTAL CIVIL	67	88	111	200	233	260	239	288	365	546	809

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
CIVIL											
AGRICULTURE	32	42	52	62	71	83	94	110	124	145	167
AIR TRANSPORT	239	313	381	450	515	599	676	790	894	1019	1190
CARGO DISTRIB	0	0	0	0	0	0	0	0	0	0	0
CONSTRUCTION	28	35	43	50	58	67	75	88	99	115	132
FORESTRY	22	31	42	53	65	79	94	114	134	162	191
OTHER	243	337	412	487	557	632	711	833	942	1097	1255
PUBLIC SRVICE	84	108	130	151	172	197	221	256	287	331	376
RESOURCE EXPL	161	212	259	307	355	414	467	549	623	727	833
TOTAL CIVIL	809	1078	1319	1560	1793	2071	2338	2740	3103	3616	4144

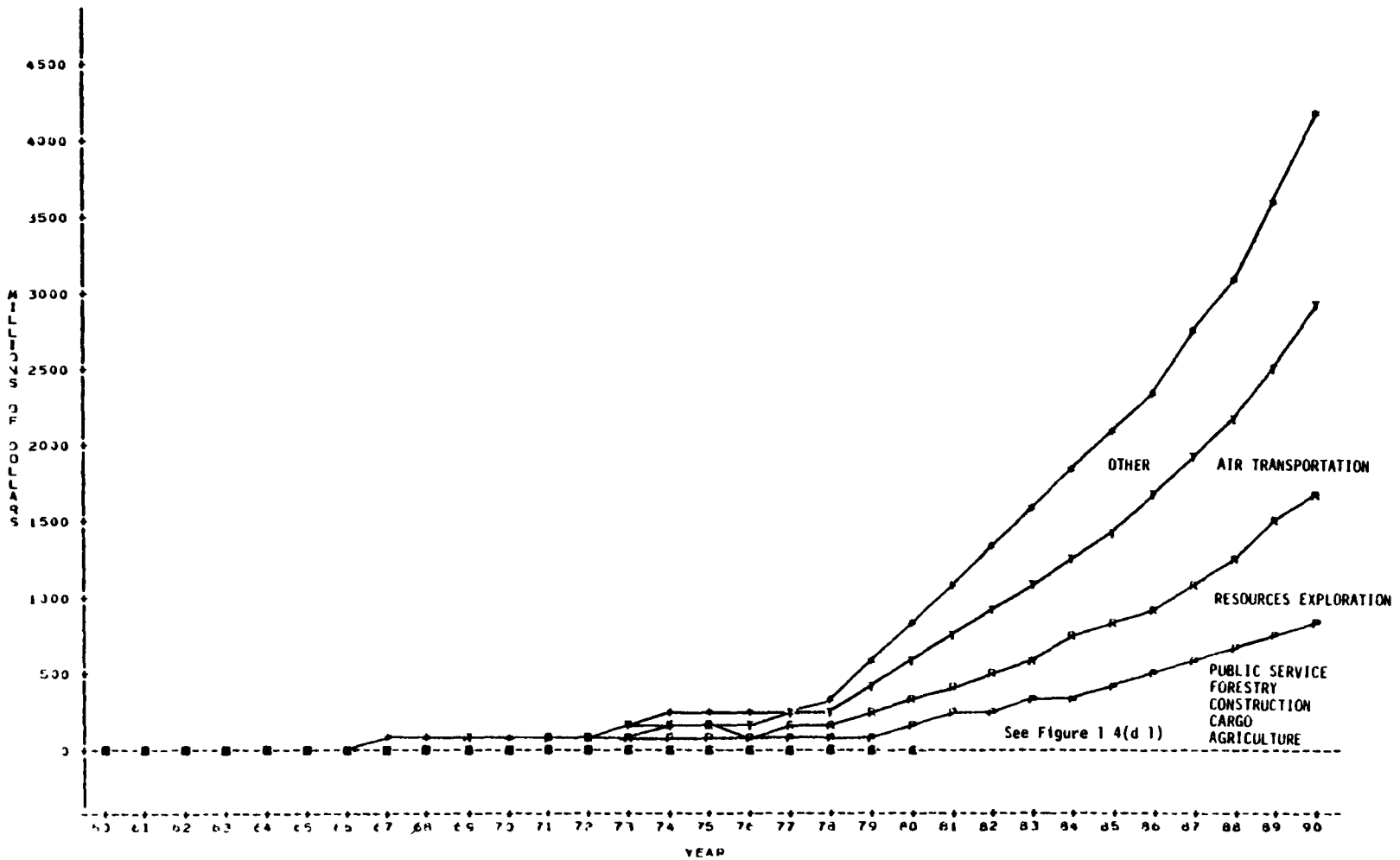

Figure 1.4(d). - Free world civil rotorcraft market by mission ($ millions).

Task 1.5 - A comparison of civil and military rotorcraft production and sales in the U.S. and Free World with general aviation, air transport, and military fixed wing vehicles for the period 1960 to 1990.

Free world general aviation and air transport projections are based upon ICAO projections contained in "The Civil Aviation Market During the Next Decade." This report states that the U.S. share is 81.2 percent of Free World General Aviation production.

U.S. General Aviation, Air Transport, and Military fixed wing production figures are derived from the annual report of Aerospace Industries Association "Aerospace Facts and Figures," FAA annual aviation forecasts, and the U.S. government and international industry publications.

In view of the 1979 backlog and the need for new fuel-efficient transport aircraft, these projections are very conservative. The estimate is 2750 new aircraft to be sold by 1988, 30 percent are replacements and 70 percent are for additional capacity. A more recent study by McDonnell Douglas Corporation projects that airline passenger traffic will more than double by 1994, calling for 6100 new aircraft. Of the 5803 aircraft in the passenger airline fleet at the end of 1979, more than 3900, or about 68 percent of the fleet are expected to be retired according to McDonnell Douglas.

The Military fixed wing forecast envisions substantial increases in cost per unit due to higher performance and more sophisticated systems.

U.S. Civil Aircraft Production (Tables/Figures 1.5a & b) - General Aviation fixed wing aircraft dominate U.S. civil aircraft unit production. In 1960, with more than 7500 units produced, they constituted nearly 95 percent of the fixed wing aircraft total. This high ratio has held ever since. By 1966, General Aviation production had more than doubled, then by 1971 it declined to its prior level. Since that time, it has continuously climbed to a level of approximately 20,000 units and is forecast to grow to more than 30,000 by 1990.

U.S. Air Transport production has fluctuated widely, varying between 100 and 700 units per year during the 1960's and currently at 230 units per year. By 1990, it is forecast to be 250 per year. The U.S. share of free world production is expected to be approximately 90 percent until the mid 1980's when introduction of the Boeing 757/767 series is expected to increase the U.S. share to 95 percent. The Air Transport projections may be conservative given the 1979 backlog of orders,

the need for new fuel-efficient aircraft, and the proliferation of feeder airlines stemming from deregulation.

Civil rotorcraft production, doubling during the 1960's and sharply increasing its rate of growth in 1979 and 1980, indicates penetration of the general aviation market with the onset of small twin engine helicopters with an IFR capability.

Free World Civil Aircraft Production (Tables/Figures 1.5 c & d) - By 1990, civil rotorcraft production is expected to exceed $3 billion per year, 17 percent of all of civil aviation production. Free world general aviation air transport and rotorcraft production are expected to generally parallel U.S. production.

Rotorcraft is the fastest growing sector, doubling unit production in the 1960's, more than doubling in the 1970's, and forecast to double again in the 1980's. They increased from 2 percent of the civil aircraft production in 1960 to more than 5 percent in 1970, more than 6 percent in 1980, and forecast to reach 7 percent by 1990. It has grown from 1 percent to nearly 10 percent over the last two decades in dollars expended and is expected to exceed 20 percent by 1990.

TABLE 1.5(a). - U. S. CIVIL AIRCRAFT PRODUCTION (UNITS)

HISTORY	60	61	62	63	64	65	66	67	68	69	70
CIVIL											
GENERAL AVIATION	7588	6778	6697	7569	9336	11852	15747	13577	13698	12457	7283
AIR TRANSPORTATION	306	198	134	100	163	233	344	480	702	514	311
ROTORCRAFT	188	281	320	382	396	340	377	419	465	434	415
TOTAL CIVIL	8082	7257	7151	8051	9895	12425	16468	14476	14865	13405	8009
TOTAL UNITED STATES	8082	7257	7151	8051	9895	12425	16468	14476	14865	13405	8009

HISTORY	70	71	72	73	74	75	76	77	78	79	80
CIVIL											
GENERAL AVIATION	7283	7466	9774	13645	14165	14057	15450	16916	17817	18186	20.95
AIR TRANSPORTATION	311	223	227	294	332	315	238	185	224	230	234
ROTORCRAFT	415	391	490	859	731	704	678	610	652	1040	1264
TOTAL CIVIL	8009	8080	10491	14798	15228	15076	16366	17705	18693	19450	21593
TOTAL UNITED STATES	8009	8080	10491	14798	15228	15076	16366	17705	18693	19450	21593

FORECAST	80	81	82	83	84	85	86	87	88	89	90
CIVIL											
GENERAL AVIATION	20095	21241	22414	23588	24761	25934	27080	28166	29190	30166	31343
AIR TRANSPORTATION	234	235	235	234	239	243	248	248	249	249	249
ROTORCRAFT	1264	1402	1481	1574	1701	1818	1914	2036	2114	2232	2342
TOTAL CIVIL	21593	22878	24130	25396	26701	27995	29242	30450	31553	32647	33934
TOTAL UNITED STATES	21593	22878	24130	25396	26701	27995	29242	30450	31553	32647	33934

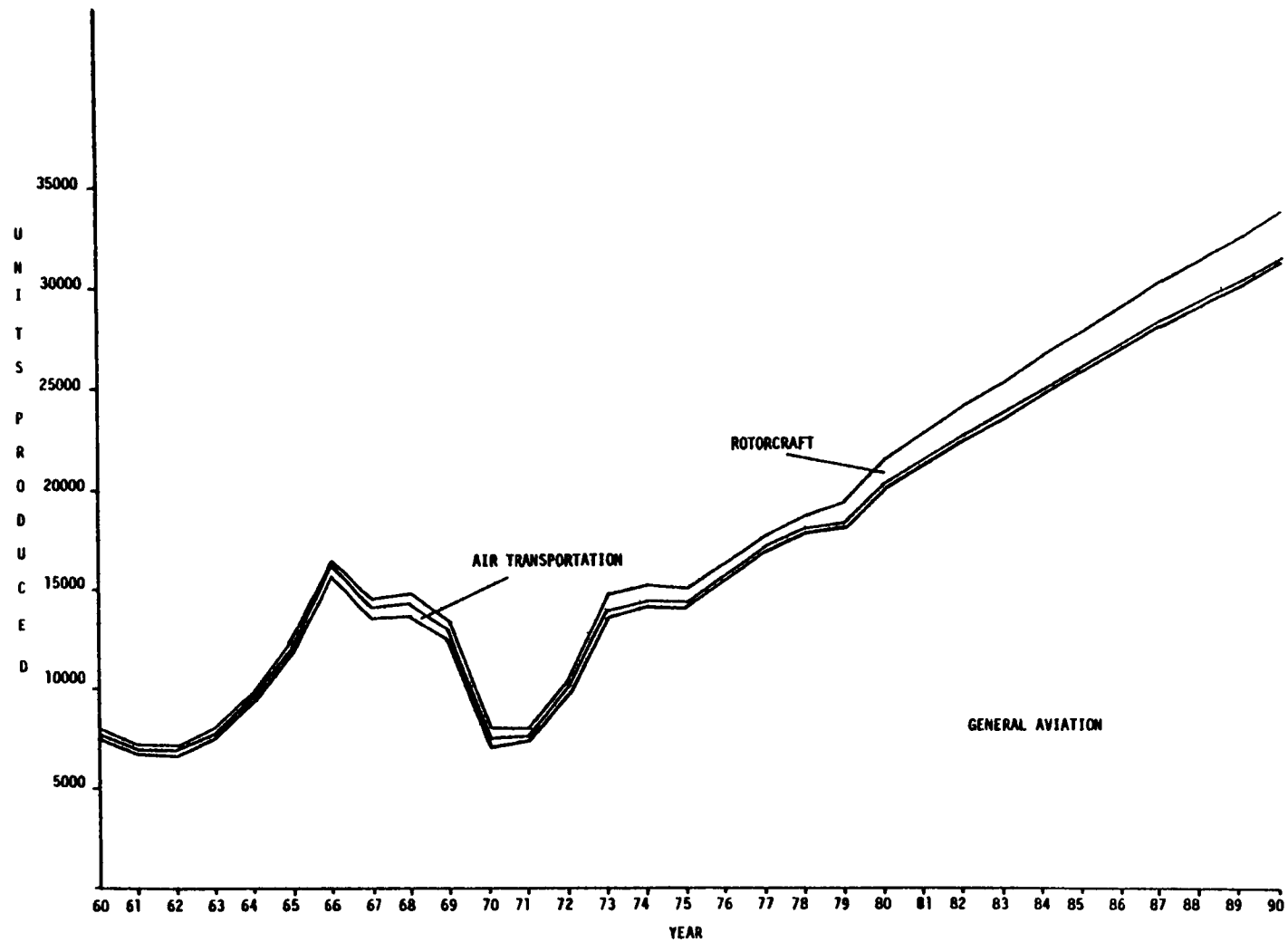

Figure 1.5(a). - U. S. civil aircraft production (units).

TABLE 1.5(b). - U. S. CIVIL AIRCRAFT SALES ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
CIVIL											
GENERAL AVIATION	151	124	137	153	199	318	444	360	421	584	339
AIR TRANSPORTATION	600	725	605	406	787	1197	1699	2458	3789	2939	3158
ROTORCRAFT	13	16	23	29	26	31	30	41	64	75	48
TOTAL CIVIL	764	865	765	588	1012	1546	2173	2859	4274	3598	3545
TOTAL UNITED STATES	764	865	765	588	1012	1546	2173	2859	4274	3598	3545

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
CIVIL											
GENERAL AVIATION	339	321	558	826	908	1033	1229	1551	1822	2100	1929
AIR TRANSPORTATION	3158	2594	2660	3718	3993	3779	3192	2889	4332	6438	4770
ROTORCRAFT	48	57	83	149	169	201	190	186	216	362	557
TOTAL CIVIL	3545	2972	3301	4693	5070	5013	4611	4626	6370	8900	7256
TOTAL UNITED STATES	3545	2972	3301	4693	5070	5013	4611	4626	6370	8900	7256

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
CIVIL											
GENERAL AVIATION	1929	2082	2241	2406	2575	2749	2871	3098	3269	3439	3636
AIR TRANSPORTATION	4778	5138	5490	5940	6480	7410	8360	8645	9070	9795	10579
ROTORCRAFT	557	755	951	1124	1299	1491	1714	2027	2305	2707	3114
TOTAL CIVIL	7256	7967	8682	9470	10354	11650	12945	13770	14644	15941	17329
TOTAL UNITED STATES	7256	7967	8682	9470	10354	11650	12945	13770	14644	15941	17329

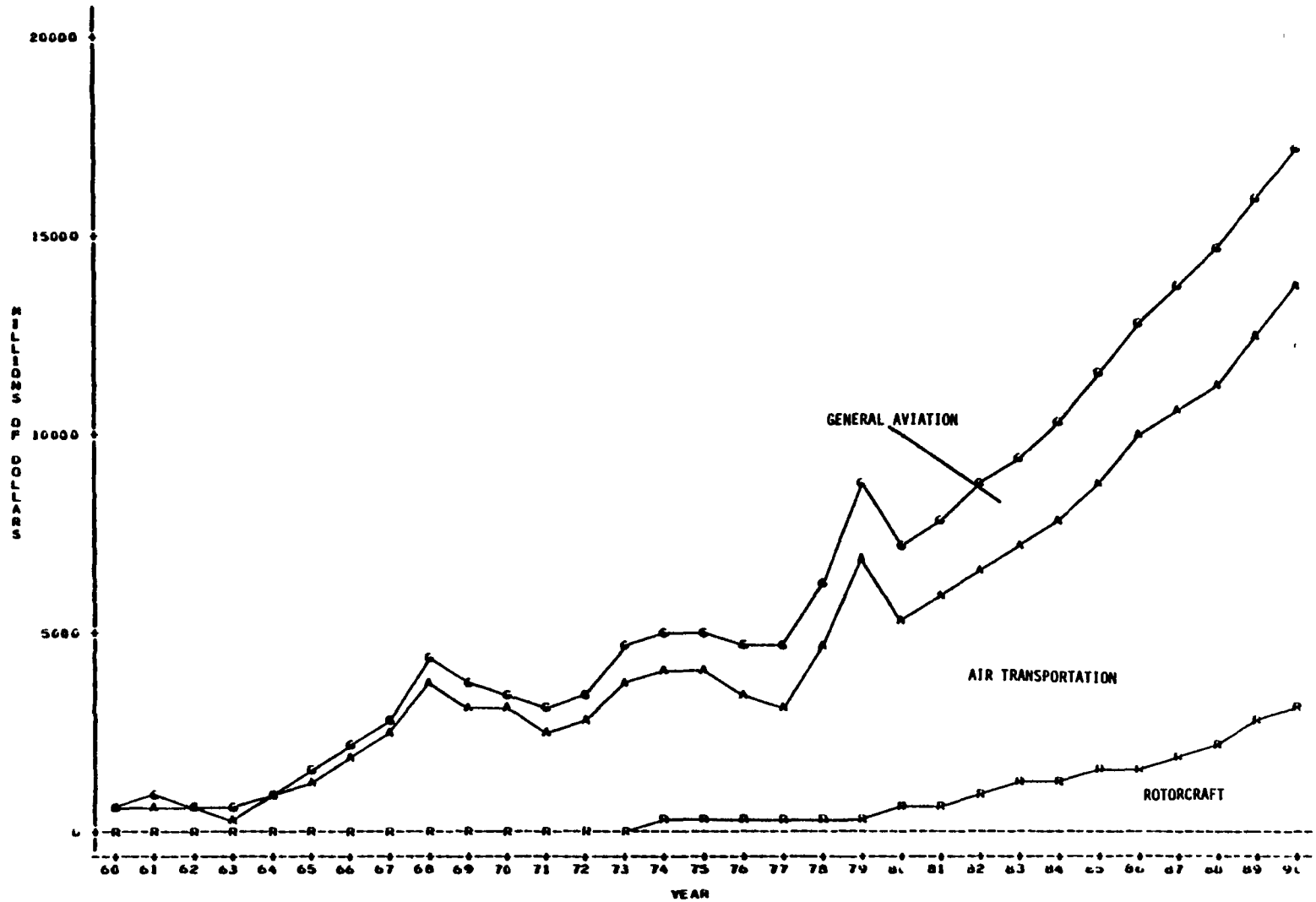

Figure 1.5(b). - U. S. civil aircraft sales ($ millions).

TABLE 1.5(c). - FREE WORLD CIVIL AIRCRAFT PRODUCTION (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
CIVIL											
GENERAL AVIATION	9345	8347	8248	9321	11498	14596	19393	16720	16869	15341	8969
AIR TRANSPORTATION	274	274	274	274	213	277	389	528	725	571	322
ROTORCRAFT	222	331	370	450	480	422	413	508	569	549	546
TOTAL CIVIL	9841	8952	8892	10045	12191	15295	20195	17756	18163	16461	9837
TOTAL FREE WORLD	9841	8952	8892	10045	12191	15295	20195	17756	18163	16461	9837

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
CIVIL											
GENERAL AVIATION	8969	9195	12037	16804	17445	17312	19027	20825	21942	22389	24748
AIR TRANSPORTATION	322	256	238	294	353	303	261	201	273	403	260
ROTORCRAFT	546	559	624	1040	914	862	803	757	838	1350	1699
TOTAL CIVIL	9837	10010	12899	18138	18712	18477	20091	21783	23053	24142	26707
TOTAL FREE WORLD	9837	10010	12899	18138	18712	18477	20091	21783	23053	24142	26707

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
CIVIL											
GENERAL AVIATION	24748	26159	27604	29049	30494	31939	33350	34687	35948	37156	38660
AIR TRANSPORTATION	260	261	261	260	260	261	261	261	262	262	262
ROTORCRAFT	1699	1851	1952	2094	2221	2369	2486	2630	2725	2863	2995
TOTAL CIVIL	26707	28271	29817	31403	32975	34569	36097	37578	38935	40275	41857
TOTAL FREE WORLD	26707	28271	29817	31403	32975	34569	36097	37578	38935	40275	41857

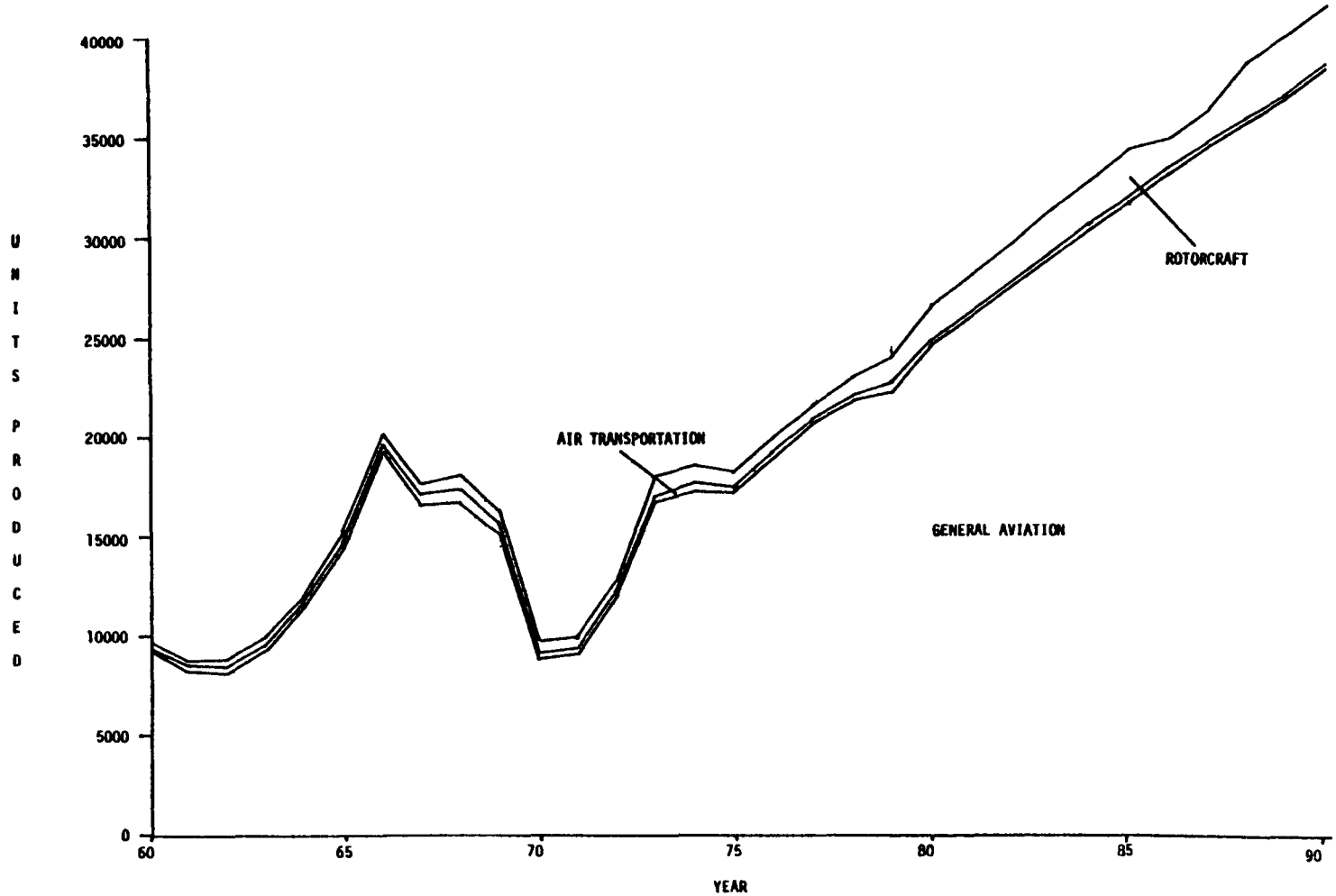

Figure 1.5(c). - Free world civil aircraft production (units).

TABLE 1.5(d). - FREE WORLD CIVIL AIRCRAFT SALES ($ MILLIONS)

HISTORY	60	61	62	63	64	65	66	67	68	69	70
CIVIL											
GENERAL AVIATION	186	153	169	188	245	392	547	443	518	719	417
AIR TRANSPORTATION	990	1006	1236	1112	1029	1424	1922	2703	3915	3266	3268
ROTORCRAFT	15	19	29	36	35	40	36	53	78	92	67
TOTAL CIVIL	1191	1178	1434	1336	1309	1856	2505	3199	4511	4077	3752
TOTAL FREE WORLD	1191	1178	1434	1336	1309	1856	2505	3199	4511	4077	3752

HISTORY	70	71	72	73	74	75	76	77	78	79	80
CIVIL											
GENERAL AVIATION	417	395	687	1017	1118	1272	1514	1910	2244	2586	2376
AIR TRANSPORTATION	3268	2977	2789	3719	4247	3636	3500	3140	4846	7153	5360
ROTORCRAFT	67	89	111	200	233	260	239	288	365	550	808
TOTAL CIVIL	3752	3461	3587	4936	5598	5168	5253	5338	7455	10289	8484
TOTAL FREE WORLD	3752	3461	3587	4936	5598	5168	5253	5338	7455	10289	8484

FORECAST	80	81	82	83	84	85	86	87	88	89	90
CIVIL											
GENERAL AVIATION	2376	2564	2760	2963	3171	3386	3535	3816	4026	4235	4478
AIR TRANSPORTATION	5300	5700	6100	6600	7200	7800	8800	9100	9547	10311	11136
ROTORCRAFT	808	1078	1320	1560	1794	2071	2337	2740	3103	3615	4143
TOTAL CIVIL	8484	9342	10180	11123	12165	13257	14672	15656	16676	18161	19757
TOTAL FREE WORLD	8484	9342	10180	11123	12165	13257	14672	15656	16676	18161	19757

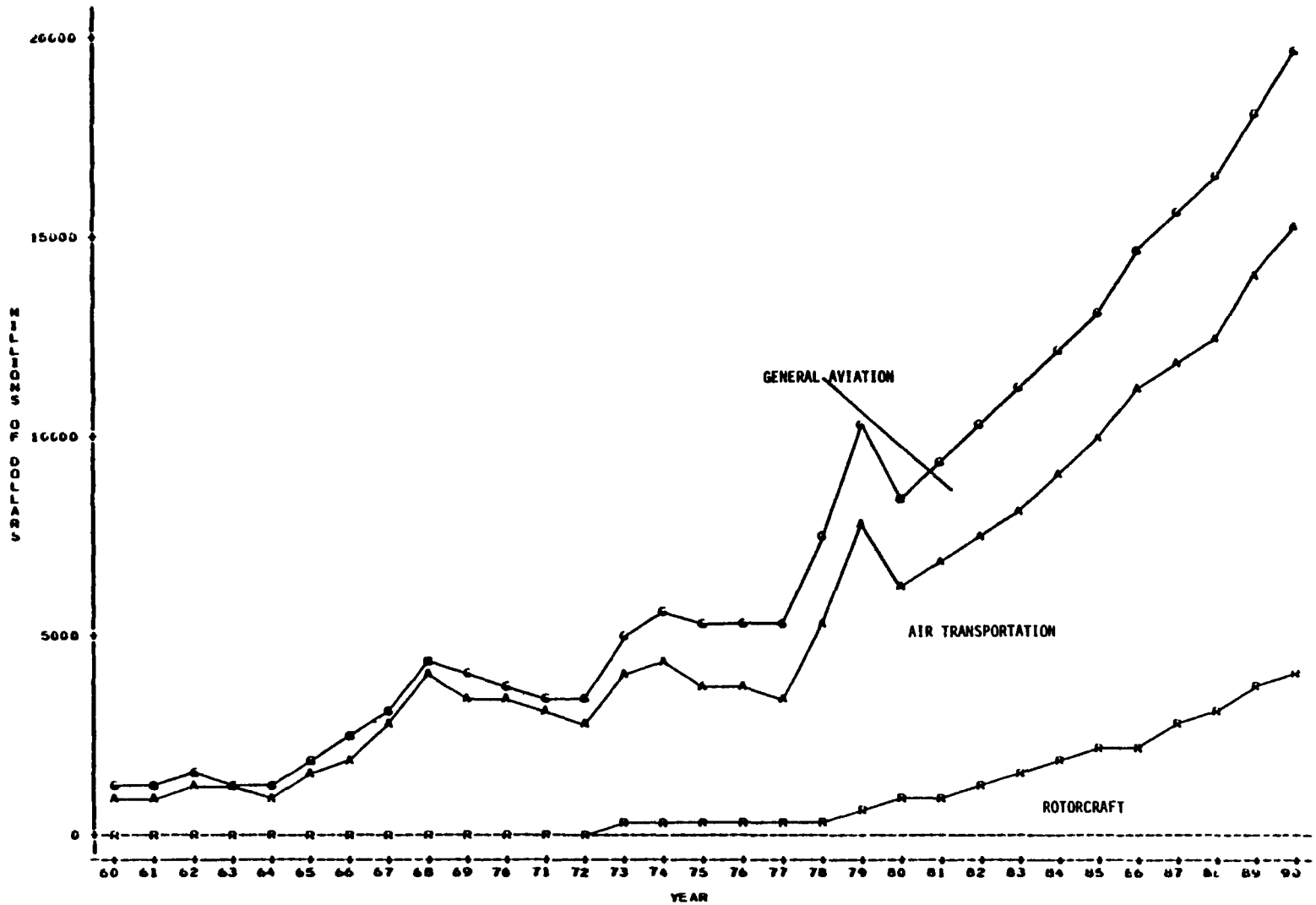

Figure 1.5(d). - Free world civil aircraft sales ($ millions).

U.S. Military Aircraft Production (Tables/Figures 1.5 e & f) - U.S. military aircraft production, slightly over 2000 units per year in 1960, increased to nearly 5000 units per year at the peak of the Vietnam buildup, declined to 830 in 1979. Under the Reagan administration this is expected to increase to a level of 1200 by 1985, declining to approximately 1000 by 1990.

Expenditures climbed from $3.3 billion in 1960 to approximately $8 billion in 1980. With increased quantities, more sophisticated equipment and inflation, expenditures are forecast to reach approximately $25 billion per year by 1990.

The rotorcraft relative rate of growth in military aviation, except for the Vietnam surge, has not been as impressive as that in civil aviation. Rotorcraft production was approximately 25 percent of the total aircraft unit production and 3 percent dollar expenditures in 1960, and is now 30 percent of total unit production and 5 percent of dollar expenditures.

By the end of the 1980's, rotorcraft production is expected to increase to more than 40 percent of total aircraft unit production and nearly 15 percent of dollar expenditures.

TABLE 1.5(e). - U. S. MILITARY AIRCRAFT PRODUCTION (UNITS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
MILITARY											
ROTORCRAFT	551	504	707	944	1232	1511	2332	2703	2681	2158	2059
FIXED WING	1568	1216	1421	1298	1432	1336	1445	2033	1640	1479	1141
TOTAL MILITARY	2119	1720	2128	2242	2664	2847	3777	4736	4321	3637	3200
TOTAL UNITED STATES	2119	1720	2128	2242	2664	2847	3777	4736	4321	3637	3200

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
MILITARY											
ROTORCRAFT	2059	1375	1257	860	422	529	439	369	356	264	364
FIXED WING	1141	645	805	564	604	768	795	589	557	576	708
TOTAL MILITARY	3200	2020	2062	1424	1026	1297	1234	958	913	840	1072
TOTAL UNITED STATES	3200	2020	2062	1424	1026	1297	1234	958	913	840	1072

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
MILITARY											
ROTORCRAFT	364	245	261	263	327	366	413	399	429	494	401
FIXED WING	708	597	821	835	850	425	751	665	672	646	588
TOTAL MILITARY	1072	842	1082	1098	1177	1211	1164	1064	1101	1140	989
TOTAL UNITED STATES	1072	842	1082	1098	1177	1211	1164	1064	1101	1140	989

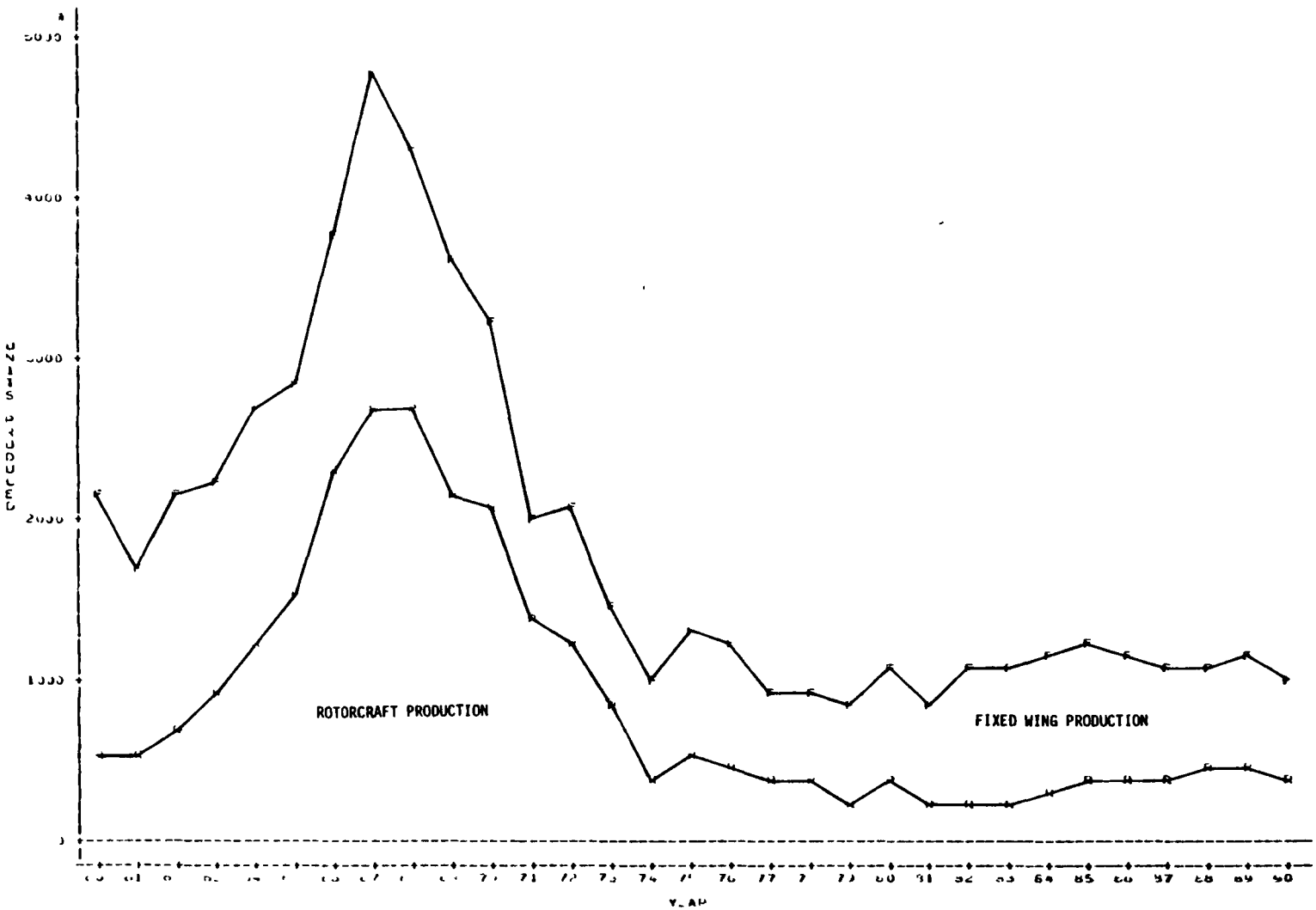

Figure 1.5(e). - U. S. military aircraft production (units).

TABLE 1.5(f). - U. S. MILITARY AIRCRAFT PRODUCTION ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
MILITARY											
ROTORCRAFT	96	130	201	301	381	540	876	1128	1585	1313	1214
FIXED WING	3211	4269	3566	2539	2724	2385	2805	3514	2966	2848	3226
TOTAL MILITARY	3307	4399	3767	2840	3105	2925	3681	4642	4551	4161	4440
TOTAL UNITED STATES	3307	4399	3767	2840	3105	2925	3681	4642	4551	4161	4440

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
MILITARY											
ROTORCRAFT	1214	743	654	421	469	551	510	456	348	324	597
FIXED WING	3226	2527	3370	2986	3970	5024	5495	4810	5510	6399	7749
TOTAL MILITARY	4440	3270	3924	3407	4439	5575	6005	5266	5858	6723	8346
TOTAL UNITED STATES	4440	3270	3924	3407	4439	5575	6005	5266	5858	6723	8346

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
MILITARY											
ROTORCRAFT	597	480	536	924	1741	2325	2614	2839	3201	3846	3323
FIXED WING	7749	8857	12981	15740	16344	18561	18568	19716	18644	21013	21325
TOTAL MILITARY	8346	9337	13517	16664	18085	20886	21182	22555	21845	24859	24648
TOTAL UNITED STATES	8346	9337	13517	16664	18085	20886	21182	22555	21845	24859	24648

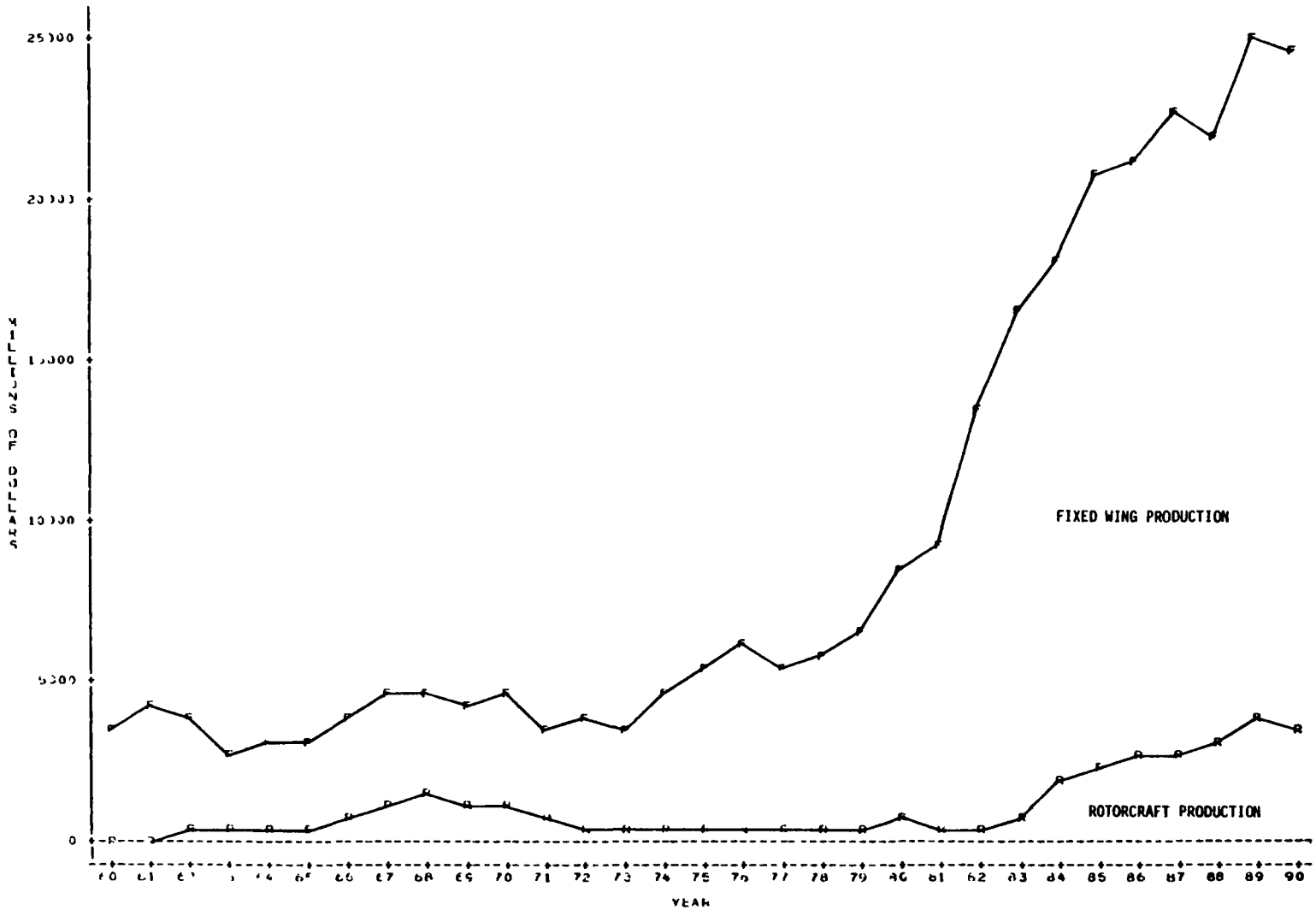

Figure 1.5(f). - U. S. military aircraft production ($ millions).

Free World Military Aircraft Production (Tables/Figures 1.5 g & h) - Free world military aircraft unit production has stabilized over the last two decades at approximately 3000 units per year, except during the Vietnam build up. It is forecast to remain at this approximate level. Dollar expenditures however have increased from $4.5 billion in 1960 to $36 billion in 1979 and forecast to reach $95 billion in 1990.

Rotorcraft share of the Free World military production decreased from a Vietnam War high of 60 percent of the units produced and 25 percent of the dollar expenditures to today's level of 25 percent of the units and 5 percent of the expenditures, the approximate level prior to the Vietnam War. This ratio is expected to hold through 1990.

TABLE 1.5(g). - FREE WORLD MILITARY AIRCRAFT PRODUCTION (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
MILITARY											
ROTORCRAFT	971	760	1156	1323	1504	1519	2732	3060	3095	2622	2612
FIXED WING	2077	2111	2154	2188	2218	2242	2266	2290	2320	2355	1647
TOTAL MILITARY	3048	2871	3310	3511	3762	4061	4998	5350	5415	4977	4259
TOTAL FREE WORLD	3048	2871	3310	3511	3762	4061	4998	5350	5415	4977	4259

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
MILITARY											
ROTORCRAFT	2612	1807	1580	1363	926	1063	901	823	730	651	671
FIXED WING	1647	1272	2393	1444	1563	1323	2393	2393	2393	2738	2102
TOTAL MILITARY	4259	3079	3973	2807	2489	2386	3294	3216	3173	3389	2773
TOTAL FREE WORLD	4259	3079	3973	2807	2489	2386	3294	3216	3173	3389	2773

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
MILITARY											
ROTORCRAFT	671	650	679	657	716	921	913	892	941	969	857
FIXED WING	2102	2150	2175	2200	2225	2250	2255	2240	2315	2330	2460
TOTAL MILITARY	2773	2800	2854	2857	2943	3171	3173	3132	3256	3299	3317
TOTAL FREE WORLD	2773	2800	2854	2857	2943	3171	3173	3182	3256	3299	3317

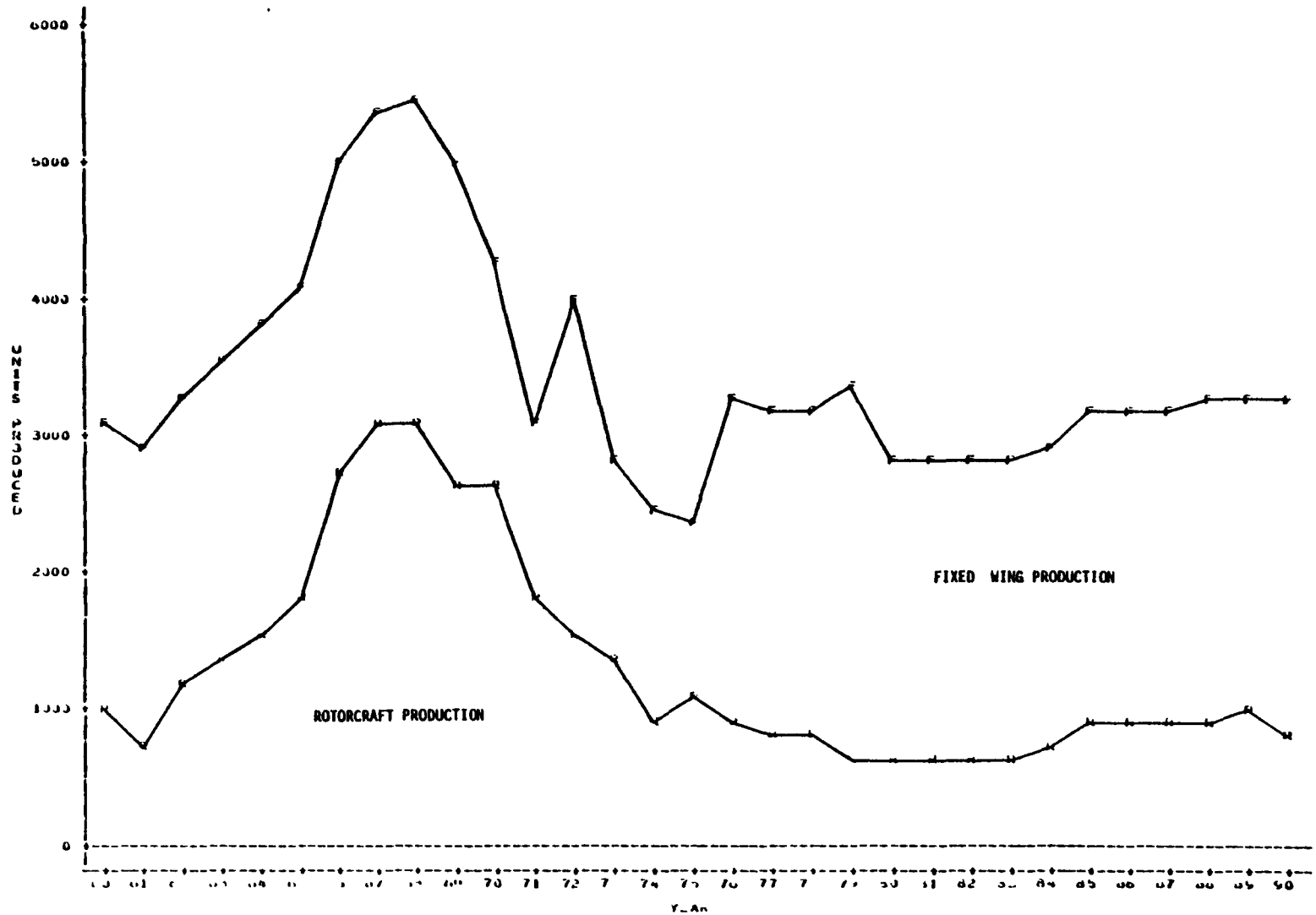

Figure 1.5(g). - Free world military aircraft production (units).

TABLE 1.5(h). - FREE WORLD MILITARY AIRCRAFT PRODUCTION ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
MILITARY											
ROTORCRAFT	208	207	263	376	475	621	973	1208	1847	1519	1583
FIXED WING	4253	7411	5406	4280	4219	4002	4399	3958	4196	4535	4657
TOTAL MILITARY	4461	7618	5669	4656	4694	4623	5372	5166	6043	6054	6240
TOTAL FREE WORLD	4461	7618	5669	4656	4694	4623	5372	5166	6043	6054	6240

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
MILITARY											
ROTORCRAFT	1583	1009	778	844	827	1076	1010	938	1068	1458	1251
FIXED WING	4657	4984	10018	7645	10274	8655	21220	27598	30350	34546	23006
TOTAL MILITARY	6240	5993	10796	8489	11101	9731	22230	28536	31418	36004	24257
TOTAL FREE WORLD	6240	5993	10796	8489	11101	9731	22230	28536	31418	36004	24257

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
MILITARY											
ROTORCRAFT	1251	1537	1569	1947	2975	4116	4582	5162	5765	6586	6088
FIXED WING	23006	31897	34389	41470	44078	50675	55754	67895	75790	87642	89215
TOTAL MILITARY	24257	33434	35958	43417	47053	54791	60336	73057	81555	94428	95303
TOTAL FREE WORLD	24257	33434	35958	43417	47053	54791	60336	73057	81555	94428	95303

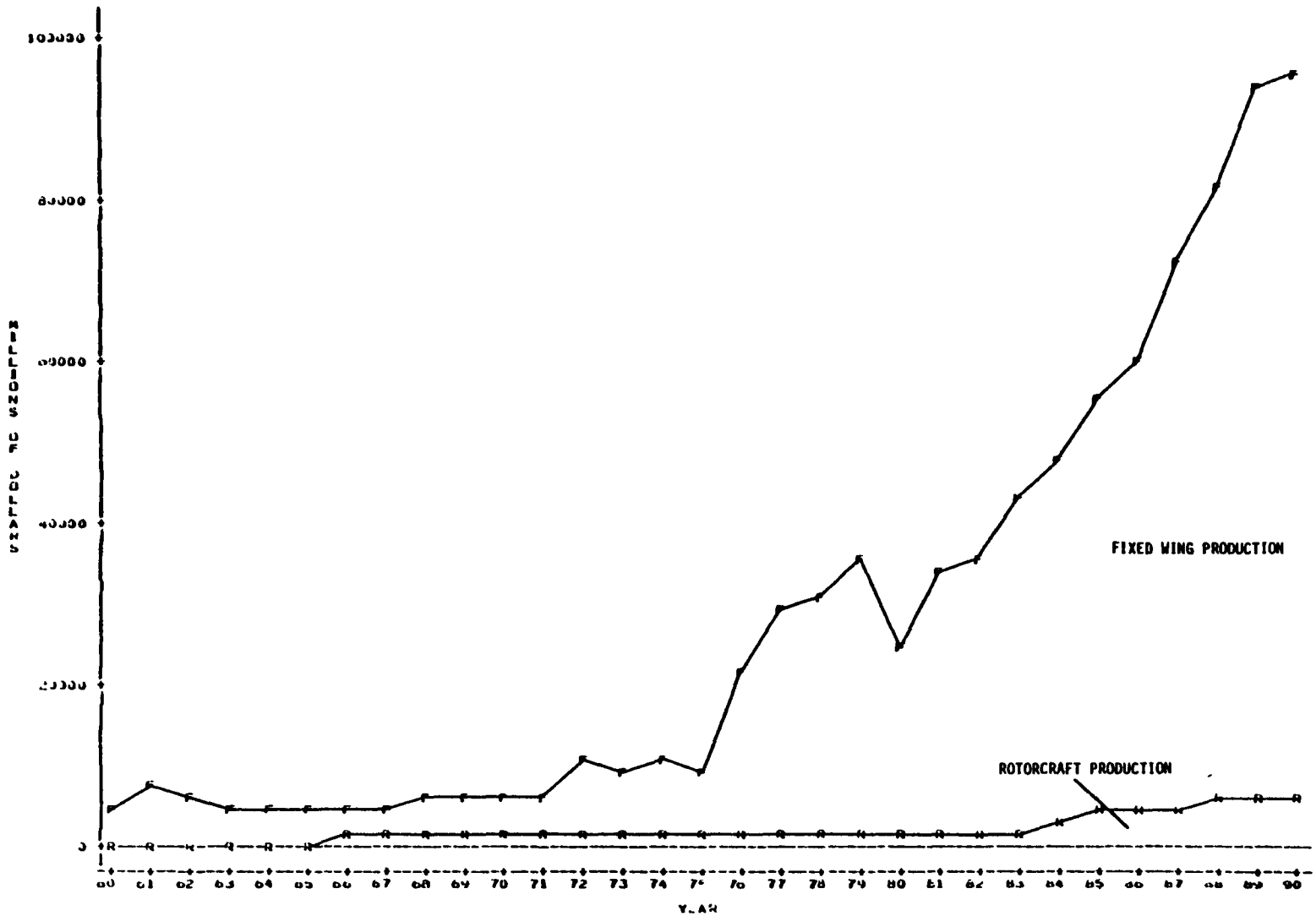

Figure 1.5(h). - Free world military aircraft production ($ millions).

Task 1.6 - Civilian and military rotorcraft fleet size for the Free World and the U.S. for the period 1960 to 1990, compared to fixed wing aircraft.

Rotorcraft Fleet Sizes

The Free World civil rotorcraft fleet increased tenfold during the period 1960-1979, while the U.S. fleet increased 12 times. These fleets should more than double in size during the next decade, with the U.S. fleet representing approximately one half of the total rotorcraft inventory, as it has throughout the reporting period (see Figure 1.6a). In comparison with fixed wing fleets (see Figure 1.6b and d), the growth of the rotorcraft fleet shows the most dramatic increase in percentage, with general aviation aircraft constituting by far the largest fleet in numbers. The air carrier fleet has shown a more modest growth, and, based on FAA and ICAO forecasts, will continue to show generally the same growth pattern, both in the U.S. and the Free World. The Free World general aviation fleet is expected to double by 1990, with the U.S. count increasing by some 52 percent. It should be noted that commuter airline aircraft data are included with general aviation figures.

Both the U.S. and Free World military rotorcraft fleet sizes were dramatically influenced by the Vietnam conflict with the Free World fleet growing by 35 percent and the U.S. fleet increasing to a peak in 1970 with a subsequent decline to two-and-one-half times its 1960 size by 1979 (see Figure 1.6c). The U.S. rotorcraft fleet is expected to remain fairly level during the next decade, with the Free World fleet showing a 23 percent increase during the same period (see Figure 1.6e and f).

The U.S. military fixed wing fleet shows a relatively steady decline through the period 1960-1979, and is expected to remain generally at current levels through 1990. The Free World military fixed wing fleet grew at an average rate of 1.4 percent per year. Due to the increasing cost of high technology, the forecast is based on a modest estimate of 1 percent per year growth, with the fleet size increasing by a total of 11.6 percent by 1990 (see Figures 1.6e and f).

TABLE 1.6(a). - FREE WORLD ACTIVE CIVIL ROTORCRAFT FLEET (UNITS)

HISTORY	60	61	62	63	64	65	66	67	68	69	70
UNITED STATES	639	786	950	1192	1420	1595	1827	2093	2389	2624	2796
FREE WORLD	1411	1738	2118	2567	3049	3476	3996	4426	4991	5564	5993

HISTORY	70	71	72	73	74	75	76	77	78	79	80
UNITED STATES	2796	3662	3479	4383	5132	5823	6251	6556	6883	7851	8476
FREE WORLD	5993	6812	7329	8567	9615	10512	11239	11917	12701	14120	15344

FORECAST	80	81	82	83	84	85	86	87	88	89	90
UNITED STATES	8476	9104	9792	10515	11285	12120	12995	13917	14869	15866	16892
FREE WORLD	15344	16679	18072	19561	21129	22793	24526	26336	28189	30121	32122

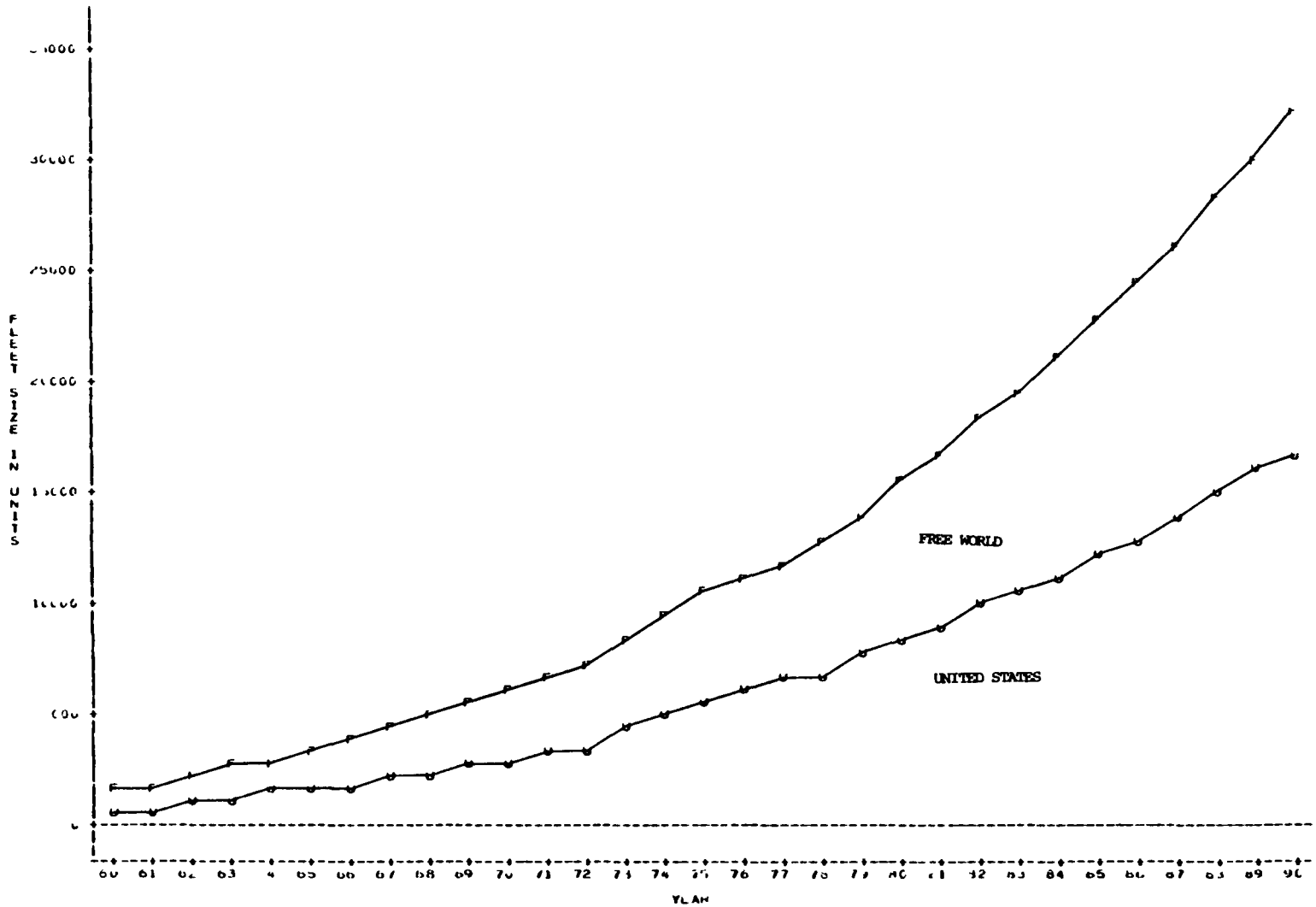

Figure 1.6(a). - Free world active civil rotorcraft fleet (units).

TABLE 1.6(b). - U. S. ACTIVE CIVIL AIRCRAFT FLEET (THOUSANDS OF UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
GENERAL AVIATION	68	77	80	83	84	87	103	112	122	128	129
AIR CARRIER	2	2	2	2	2	2	2	2	3	3	3
ROTORCRAFT	1	1	1	1	1	2	2	2	2	3	3
TOTAL UNITED STATES	71	80	83	86	87	91	107	116	127	134	135

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
GENERAL AVIATION	129	129	141	149	155	161	170	176	194	201	209
AIR CARRIER	3	3	3	3	2	2	2	2	2	3	3
ROTORCRAFT	3	3	3	4	5	6	6	7	7	8	8
TOTAL UNITED STATES	135	135	147	156	162	169	178	185	203	212	220

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
GENERAL AVIATION	209	217	226	235	244	253	263	273	284	295	307
AIR CARRIER	3	3	3	3	3	3	3	3	3	3	3
ROTORCRAFT	8	9	10	10	11	12	13	14	15	16	17
TOTAL UNITED STATES	220	229	239	248	258	268	279	290	302	314	327

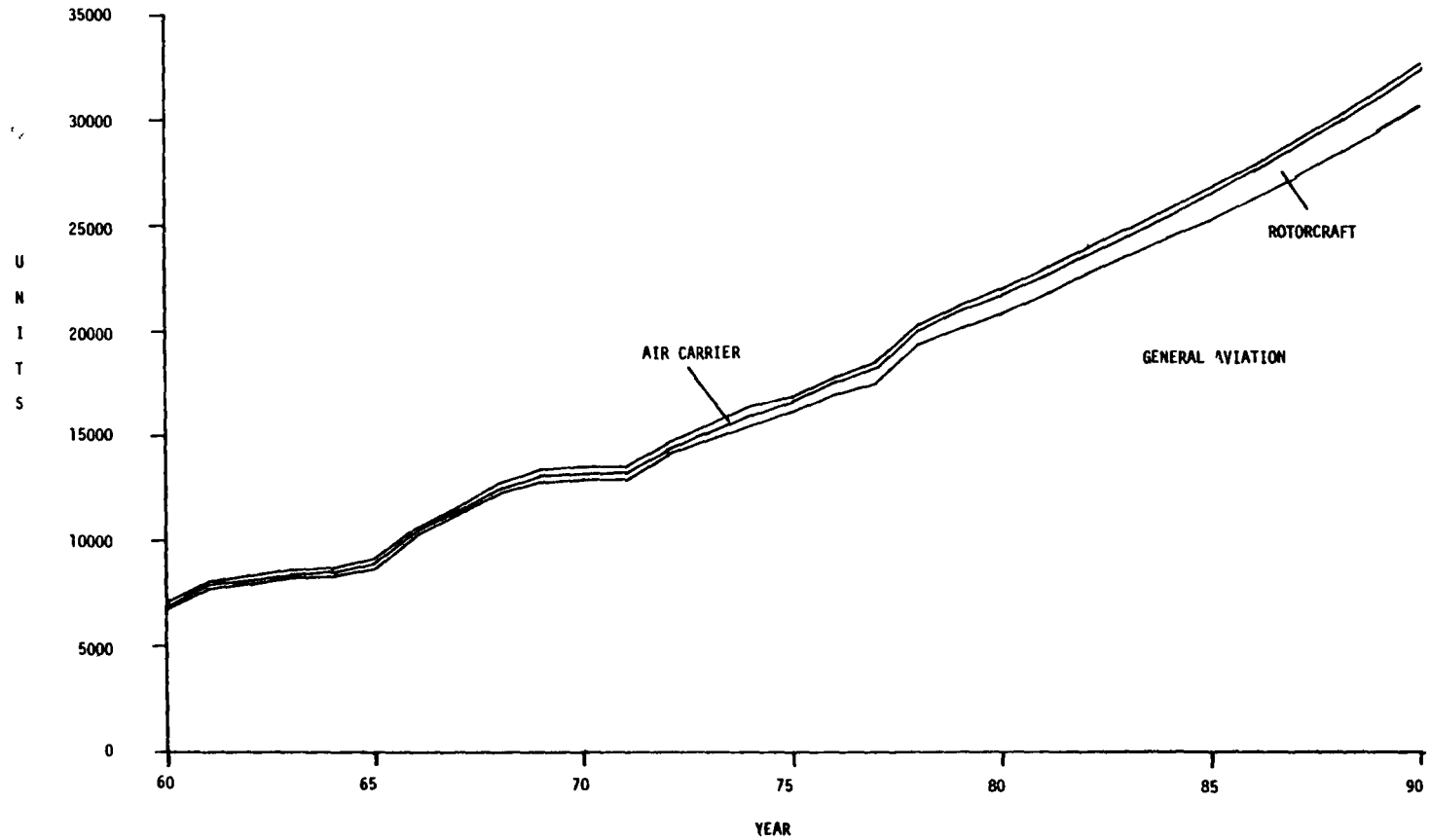

Figure 1.6(b). - U.S. active civil aircraft fleet (thousands of units).

TABLE 1.6(c). - FREE WORLD ACTIVE MILITARY ROTORCRAFT FLEET (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
UNITED STATES	3740	4645	4441	5675	5995	7663	8823	10539	11837	12561	12989
FREE WORLD	5739	6367	7273	8421	9738	11156	13346	15316	16971	18155	19116

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
UNITED STATES	12969	12416	12032	11612	11297	10760	10238	9880	9632	9499	9532
FREE WORLD	19116	19426	19609	19847	19760	19721	19729	19810	19892	20153	20512

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
UNITED STATES	9532	9494	9462	9445	9469	9560	9677	9761	9869	9995	10017
FREE WORLD	20512	20844	21260	21536	21914	22492	23059	23592	24165	24757	25236

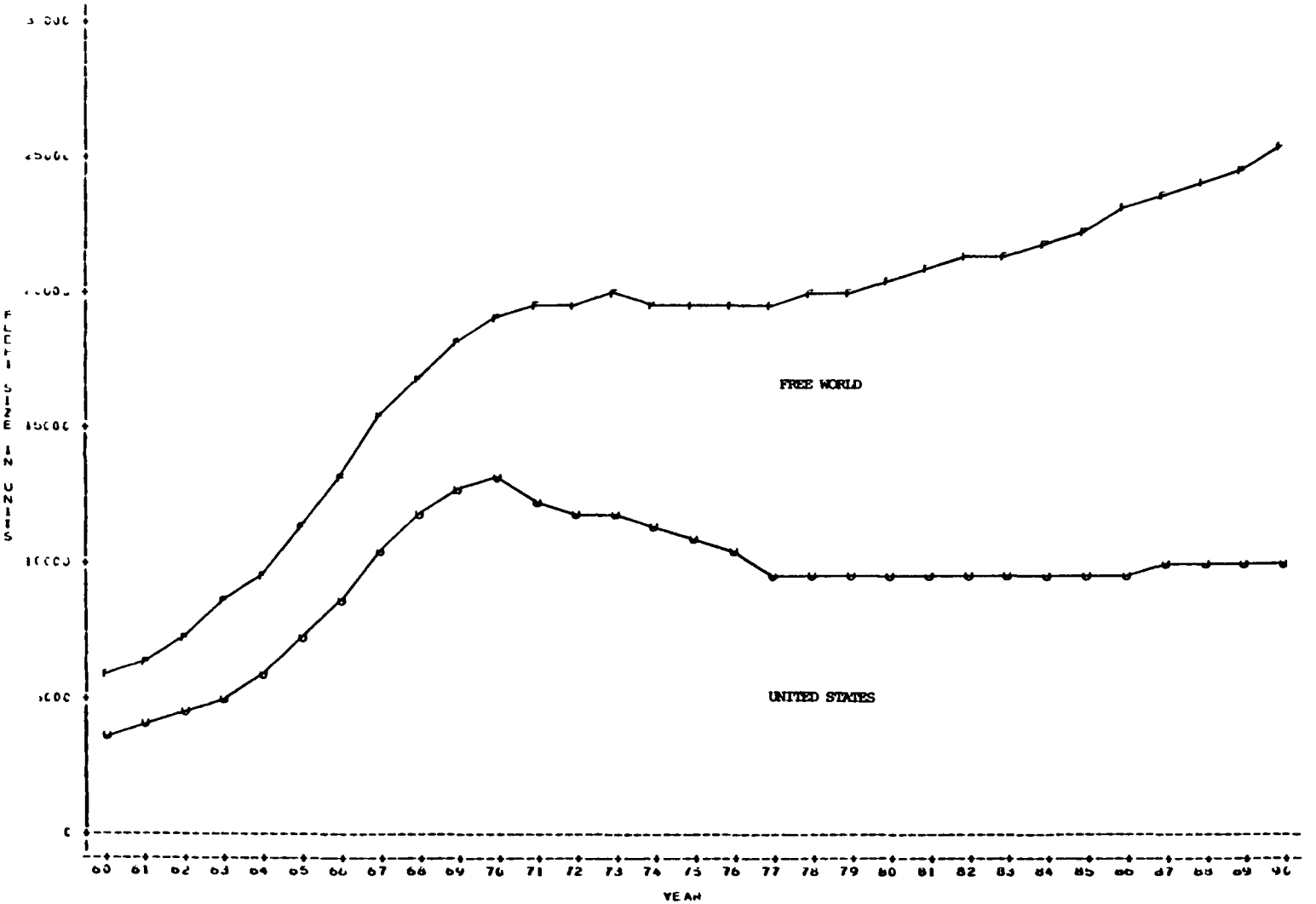

Figure 1.6(c). - Free world active military rotorcraft fleet (units).

TABLE 1.6(d). - FREE WORLD ACTIVE CIVIL AIRCRAFT FLEET (THOUSANDS OF UNITS)

HISTORY	60	61	62	63	64	65	66	67	68	69	70
GENERAL AVIATION	82	85	90	96	105	113	125	143	154	163	166
AIR CARRIER	4	5	5	5	5	6	6	6	7	7	7
ROTORCRAFT	1	2	2	3	3	3	4	4	5	5	6
TOTAL FREE WORLD	87	92	97	106	113	122	135	153	166	175	179

HISTORY	70	71	72	73	74	75	76	77	78	79	80
GENERAL AVIATION	166	193	201	213	224	236	252	264	279	300	322
AIR CARRIER	7	7	7	8	8	8	8	8	8	9	9
ROTORCRAFT	6	7	7	9	10	10	11	12	13	14	15
TOTAL FREE WORLD	179	207	215	230	242	256	271	284	300	323	346

FORECAST	80	81	82	83	84	85	86	87	88	89	90
GENERAL AVIATION	322	346	371	397	424	453	483	514	547	580	615
AIR CARRIER	9	9	9	9	10	10	10	10	10	10	11
ROTORCRAFT	15	17	18	20	21	23	24	26	28	30	32
TOTAL FREE WORLD	346	372	398	426	455	486	517	550	585	620	658

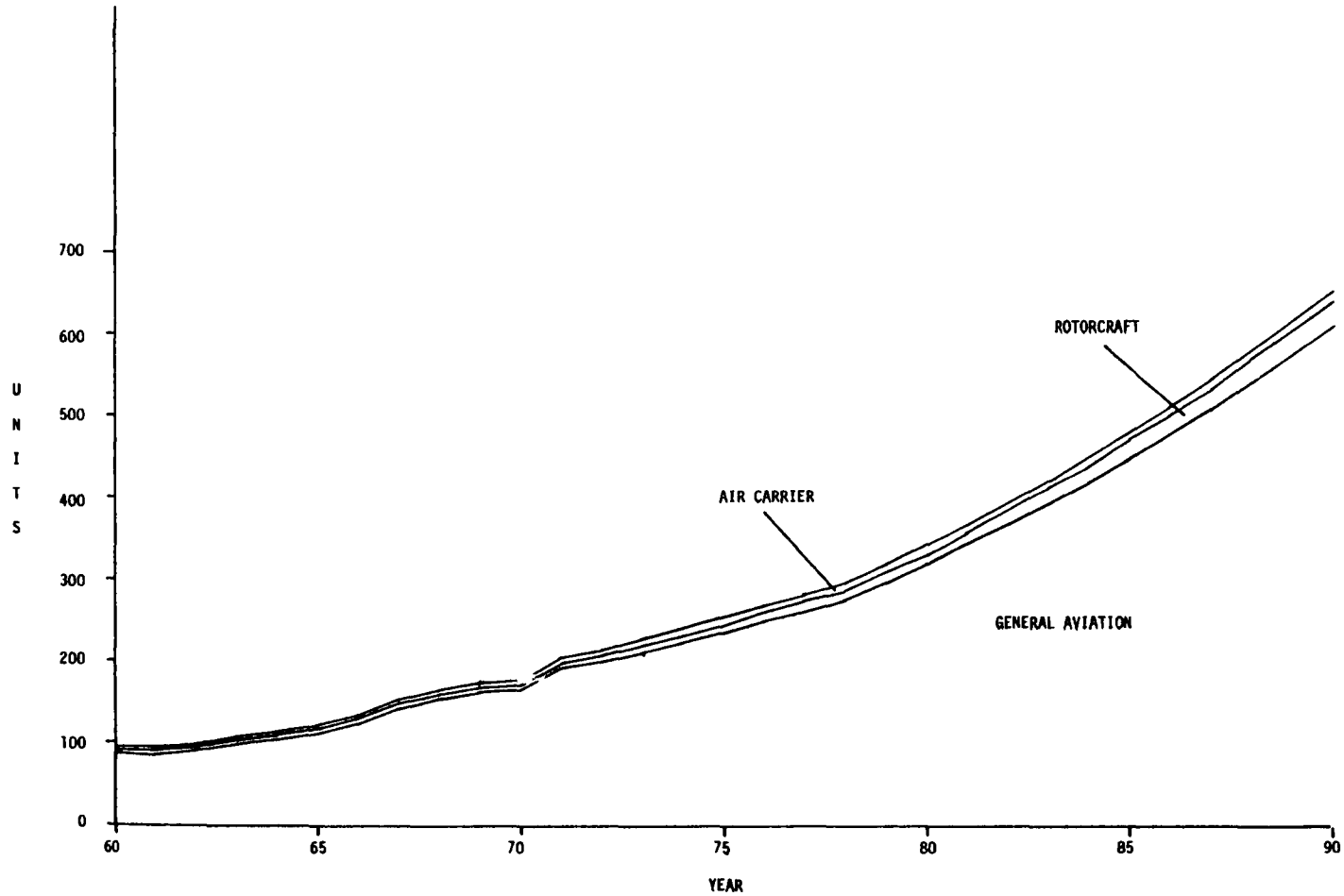

Figure 1.6(d). - Free world active civil aircraft fleet (thousands of units).

TABLE 1.6(e). - U. S. ACTIVE MILITARY FLEET (UNITS)

HISTORY

	60	61	62	63	64	65	66	67	68	69	70
MILITARY											
ROTORCRAFT	3746	4045	4441	5073	5993	7063	8023	10509	11837	12561	12969
FIXED WING	29062	27217	26974	25766	24116	22594	22137	22360	21727	21438	20862
TOTAL MILITARY	32742	31262	31415	30751	30109	29657	30160	32869	33564	33997	33831

HISTORY

	70	71	72	73	74	75	76	77	78	79	80
MILITARY											
ROTORCRAFT	12969	12411	12032	11612	11297	10700	10238	9886	9834	9499	9532
FIXED WING	20862	17849	14859	14617	13962	13275	13211	12031	12991	12755	12743
TOTAL MILITARY	33831	30259	26891	26229	25259	23975	23449	21917	22825	22254	22275

FORECAST

	80	81	82	83	84	85	86	87	88	89	90
MILITARY											
ROTORCRAFT	9532	9494	9462	9445	9464	9506	9577	9781	9865	9999	10117
FIXED WING	12743	13017	13313	13742	13976	13991	13976	13864	13851	13866	13923
TOTAL MILITARY	22275	22511	22775	23187	23377	23551	23675	23645	23716	23867	24040

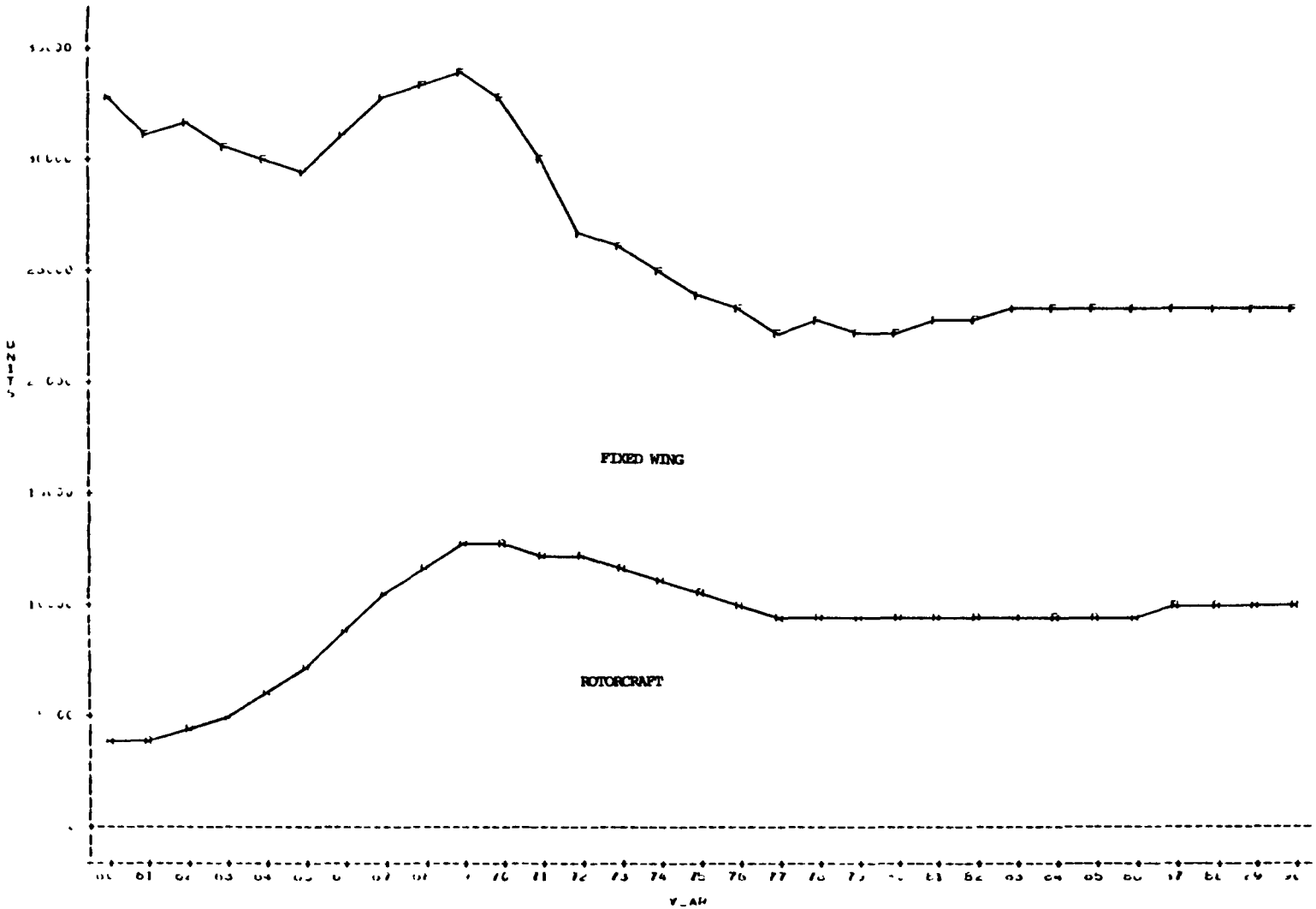

Figure 1.6(e). - U. S. active military fleet (units).

TABLE 1.6(f). - FREE WORLD ACTIVE MILITARY AIRCRAFT FLEET (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
MILITARY											
ROTORCRAFT	5739	6367	7273	8421	9738	11158	13346	15316	16971	18155	19116
FIXED WING	30768	33211	33688	34163	34653	35158	35623	36166	36598	37096	37966
TOTAL MILITARY	36507	39585	40961	42589	44391	46296	48969	51424	53569	55253	56616

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
MILITARY											
ROTORCRAFT	19116	19426	19669	19847	19760	19721	19729	19611	19692	20153	20514
FIXED WING	36966	36354	39821	39360	38917	38924	41616	42739	41413	42049	42469
TOTAL MILITARY	56616	55716	59490	59147	58677	58645	61647	62349	61305	62202	62981

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
MILITARY											
ROTORCRAFT	20512	20844	21260	21750	21914	22492	23096	23592	24165	24757	25350
FIXED WING	42469	42894	43323	43756	44194	44636	45082	45533	45988	46448	46913
TOTAL MILITARY	62981	63738	64583	65506	66108	67128	68141	69125	70153	71205	72263

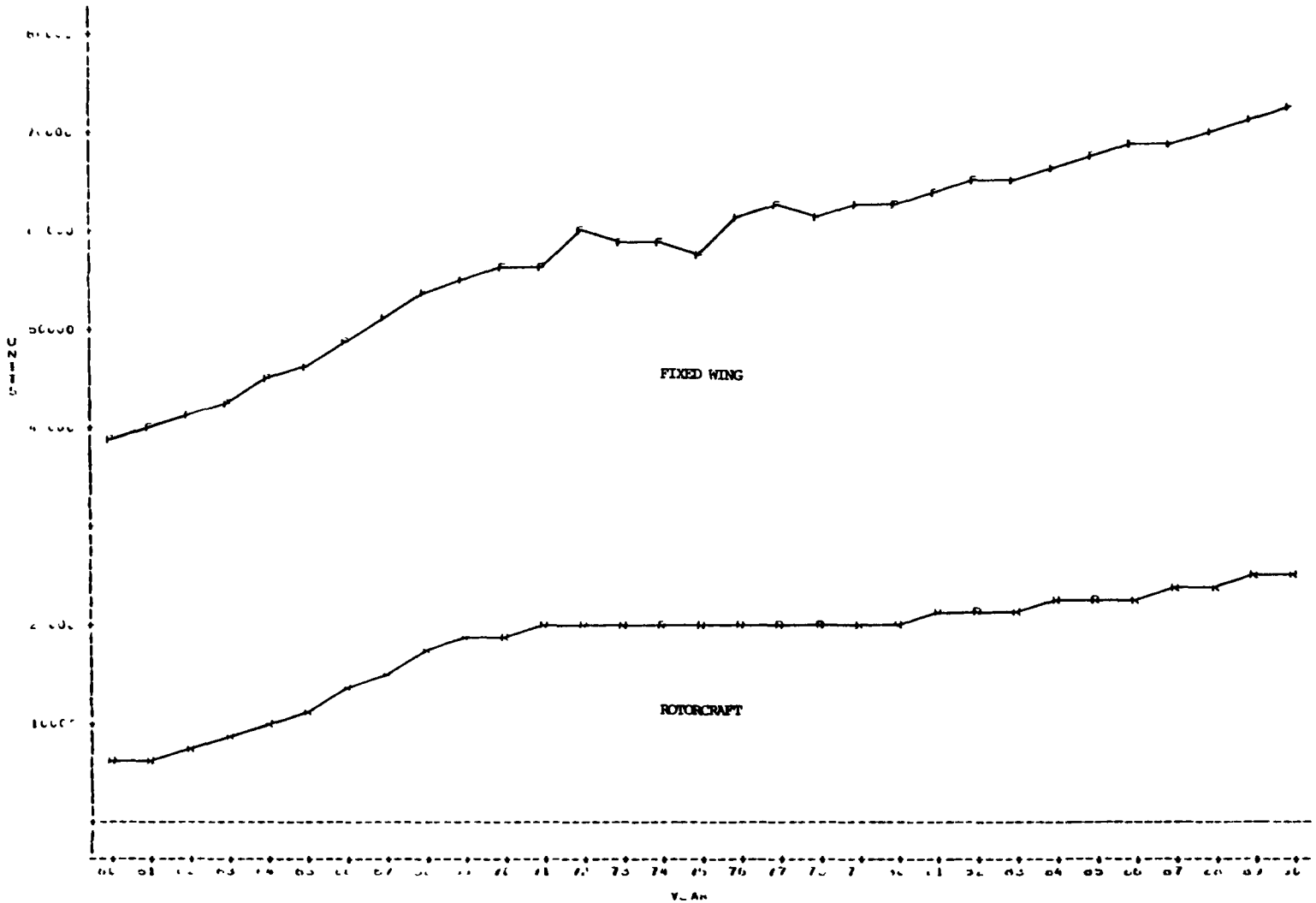

Figure 1.6(f). - Free world active military aircraft fleet (units).

Task 1.7 - Determination of number of years to retirement for rotorcraft, and portions of new growth and replacement growth added to U.S. and Free World fleets each year for the period 1960 through 1990.

Market Penetration by Foreign Manufacturers - Tables 1.7(a 2) and 1.7(a 3) show the percent of helicopters in a given year which are still in service. It is to be noted that 94 percent of the civil rotorcraft operating in the United States that were manufactured in 1960 are still flying, while 83 percent of those operating in the Free World and manufactured at the same time are still flying.

For U.S. military aircraft, the attrition of those manufactured in the 1960's is much higher because of the Vietnam War. However, those manufactured in the 1970's show a lower rate than civil aircraft, a reflection of lower flight hours.

These very low attrition rates are a distortion, reflecting a very widespread rotorcraft rebuilding activity, particularly in the United States and particularly with older, simpler models such as the Bell Model 47, the Hiller UH-12, the Hughes 269, and the Aerospatiale Alouette II. Obviously, many are completely rebuilt from the nameplate up, using nonstandard and military surplus parts. For example, in 1973 - the last year Bell built Model 47's - there were approximately 1,350 registered with the FAA. In 1979, there were approximately 1,625.

Figure 1.7(a) and Tables 1.7(a) and 1.7(a 1) reflect a forecast of the expected average life span of helicopters manufactured in any given year, based on the attrition reflected in Tables 1.7(a 2) and 1.7(a 3). An exponential formula was used:

$$F(t) = 1 - e^{-\lambda t}$$

$F(t)$ = Fraction destroyed by 1980

t = Years prior to 1980

Solving for $\frac{1}{\lambda}$, the mean age of destruction

$$\frac{1}{\lambda} = \frac{-1}{\ln(1-F(t))}$$

As mentioned earlier, the data applied to this formula is distorted, yielding a much too high expected average life span. A much more detailed and selective study would be required to yield accurate projections.

Tables/Figures 1.7(b & c) reflect the U.S. and Free World Civil Rotorcraft new growth and replacement growth history and projections. It is to be noted that attrition replacement has been negative often in the past. This actually is caused by an increase in inventory which in turn is caused by the introduction of used helicopters in excess of attrition. It is a reflection of the large number of surplus military helicopters entering the civil inventory together with helicopters "rebuilt" from surplus military spare parts.

Table 1.7(c 2) shows the relationship between inventories, attrition and the introduction of used helicopters for the Free World.

It is to be noted that "negative attrition" disappears as the large military surpluses resulting from Vietnam are exhausted.

Table 1.7(d & e) reflect the U.S. and Free World military rotorcraft. It is to be noted that in both cases inventories decrease during the 1970's, due to reduced force levels after Vietnam, and that new growth in the U.S. has been nonexistent as new deliveries have not replaced attrition.

TABLE 1.7(a). - EXPECTED AVERAGE LIFESPAN OF HELICOPTERS MANUFACTURED IN A GIVEN YEAR FREE WORLD

	60	61	62	63	64	65	66	67	68	69	70
MILITARY	18.99	16.02	17.10	19.45	19.90	21.10	21.45	18.47	22.27	24.05	54.00
CIVIL	111.30	10.25	82.64	25.79	86.10	93.63	73.65	64.16	76.28	63.77	62.21
TOTAL FREE WORLD	24.42	25.37	23.32	27.65	25.89	25.88	24.22	21.17	25.64	27.45	55.27

	70	71	72	73	74	75	76	77	78	79	80
MILITARY	54.00	102.46	68.79	115.78	234.74	74.29	40.35	160.66	368.50	1299	9999
CIVIL	62.21	74.60	79.24	82.35	98.30	95.74	79.67	80.64	94.95	34.00	9999
TOTAL FREE WORLD	55.27	94.28	71.47	98.62	139.70	80.50	51.21	112.97	149.99	41.22	9999

TABLE 1.7(a 1). - EXPECTED AVERAGE LIFESPAN OF HELICOPTERS MANUFACTURED IN A GIVEN YEAR UNITED STATES

	60	61	62	63	64	65	66	67	68	69	70
MILITARY	9.98	9.37	13.33	15.24	15.67	17.35	19.37	16.59	18.78	18.70	43.74
CIVIL	325.39	177.81	120.06	307.99	269.48	283.48	189.17	197.67	123.85	92.27	120.31
TOTAL UNITED STATES	15.30	17.05	19.23	22.61	20.80	20.32	21.69	18.64	21.18	21.10	46.91

	70	71	72	73	74	75	76	77	78	79	80
MILITARY	43.74	12.66	56.38	12.72	349.99	72.99	32.49	50.00	89.00	251.00	9999
CIVIL	120.31	93.09	108.15	119.73	120.39	111.52	113.36	154.44	106.50	414.00	9999
TOTAL UNITED STATES	46.91	109.30	62.63	115.78	150.02	141.42	136.43	173.99	171.50	381.40	9999

TABLE 1.7(a 2). - PERCENT OF HELICOPTERS MANUFACTURED IN A GIVEN YEAR WHICH ARE STILL IN SERVICE - FREE WORLD

	60	61	62	63	64	65	66	67	68	69	70
MILITARY	33.09	28.68	32.93	40.38	42.55	46.84	49.69	46.85	55.79	60.72	81.57
CIVIL	82.81	84.19	79.46	86.67	82.08	84.32	81.57	80.40	84.33	82.85	83.79
TOTAL FREE WORLD	42.32	45.45	44.27	52.15	51.66	53.88	53.82	51.62	60.22	64.58	81.95

	70	71	72	73	74	75	76	77	78	79	80
MILITARY	81.57	90.70	87.74	93.32	97.06	97.84	99.22	97.81	99.23	99.65	100.00
CIVIL	83.79	87.46	89.26	90.74	93.13	93.93	93.93	95.13	96.89	99.40	100.00
TOTAL FREE WORLD	81.95	89.94	88.17	92.21	95.11	96.09	96.75	96.52	98.02	99.55	100.00

TABLE 1.7(a 3). - PERCENT OF HELICOPTERS MANUFACTURED IN A GIVEN YEAR WHICH ARE STILL IN SERVICE - UNITED STATES

	60	61	62	63	64	65	66	67	68	69	70
MILITARY	12.20	11.83	24.04	30.89	33.79	39.77	46.10	43.01	50.04	52.65	77.77
CIVIL	93.75	89.36	85.37	94.32	93.69	94.51	92.38	93.16	90.04	87.80	91.26
TOTAL UNITED STATES	25.34	30.94	37.22	45.10	44.16	45.50	50.40	47.18	54.12	56.62	79.10

	70	71	72	73	74	75	76	77	78	79	80
MILITARY	77.77	91.51	85.25	93.35	98.02	97.83	96.21	98.86	98.43	99.21	100.00
CIVIL	91.26	89.01	92.02	93.54	94.35	94.76	95.69	97.44	98.21	99.52	100.00
TOTAL UNITED STATES	79.10	91.26	86.62	93.32	95.44	95.85	96.40	97.73	98.27	99.48	100.00

TABLE 1.7(b). - U. S. CIVIL ROTORCRAFT NEW GROWTH & REPLACEMENT GROWTH

	60	61	62	63	64	65	66	67	68	69	70
START OF YEAR INVENTORY	529	639	780	956	1192	1420	1599	1827	2093	2389	2624
ATTRITION REPLACEMENT	-14	1	-12	-7	1	15	0	-30	-14	12	44
NEW GROWTH	96	141	164	229	228	164	228	236	282	235	166
END OF YEAR INVENTORY	639	780	956	1192	1420	1599	1827	2093	2389	2624	2790

	70	71	72	73	74	75	76	77	78	79	80
START OF YEAR INVENTORY	2624	2790	3082	3479	4383	5132	5823	6251	6556	6883	7851
ATTRITION REPLACEMENT	44	-76	-133	-345	-260	-266	-24	47	65	-133	262
NEW GROWTH	166	216	264	559	489	425	404	305	327	835	625
END OF YEAR INVENTORY	2790	3082	3479	4383	5132	5823	6251	6556	6883	7851	8476

	80	81	82	83	84	85	86	87	88	89	90
START OF YEAR INVENTORY	7851	8476	9104	9792	10515	11285	12120	12995	13917	14869	15860
ATTRITION REPLACEMENT	262	282	303	325	349	375	402	430	460	490	523
NEW GROWTH	625	628	688	723	770	835	875	922	952	991	1032
END OF YEAR INVENTORY	8476	9104	9792	10515	11285	12120	12995	13917	14869	15860	16892

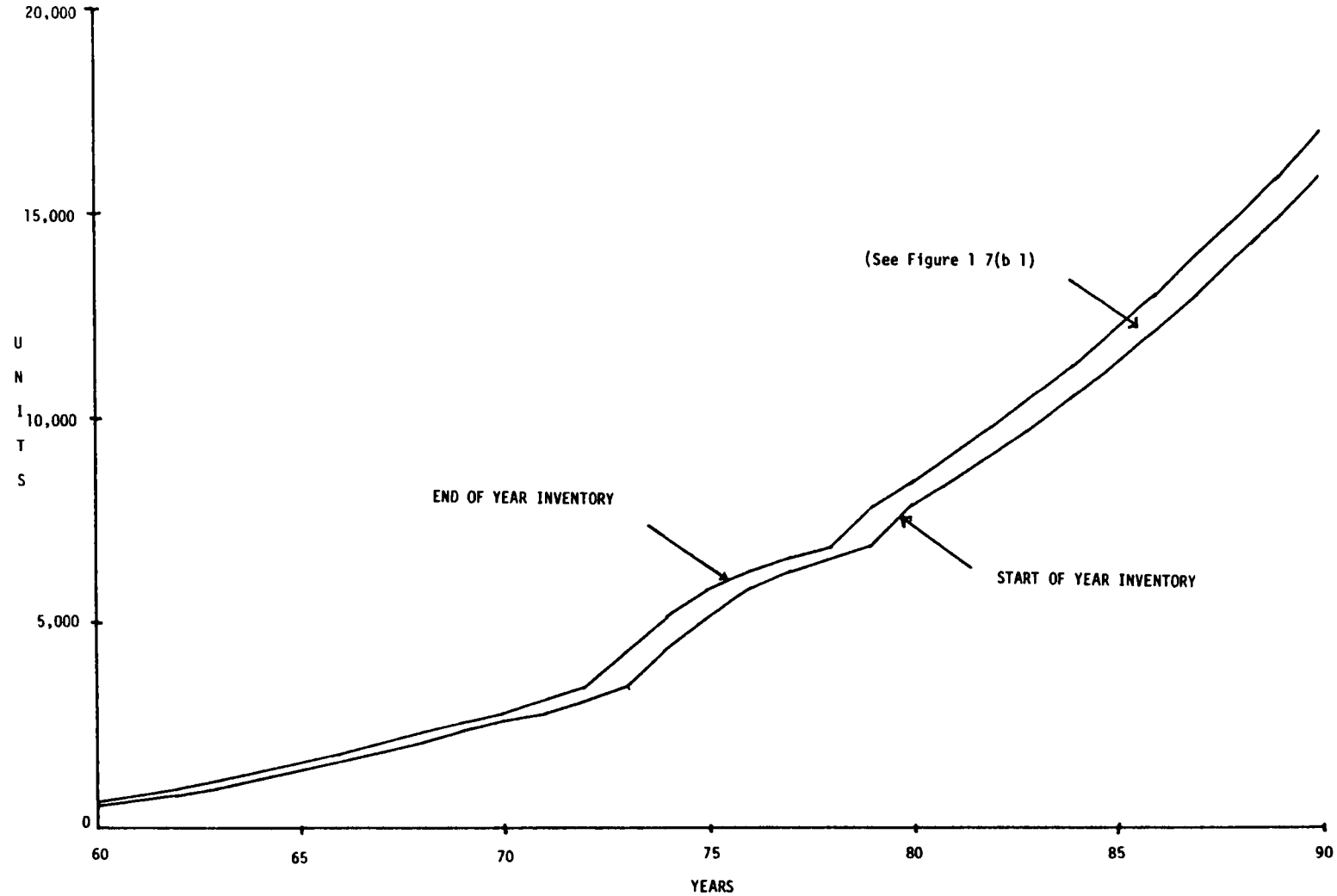

Figure 1.7(b). - U. S. civil rotorcraft new growth & replacement growth (units).

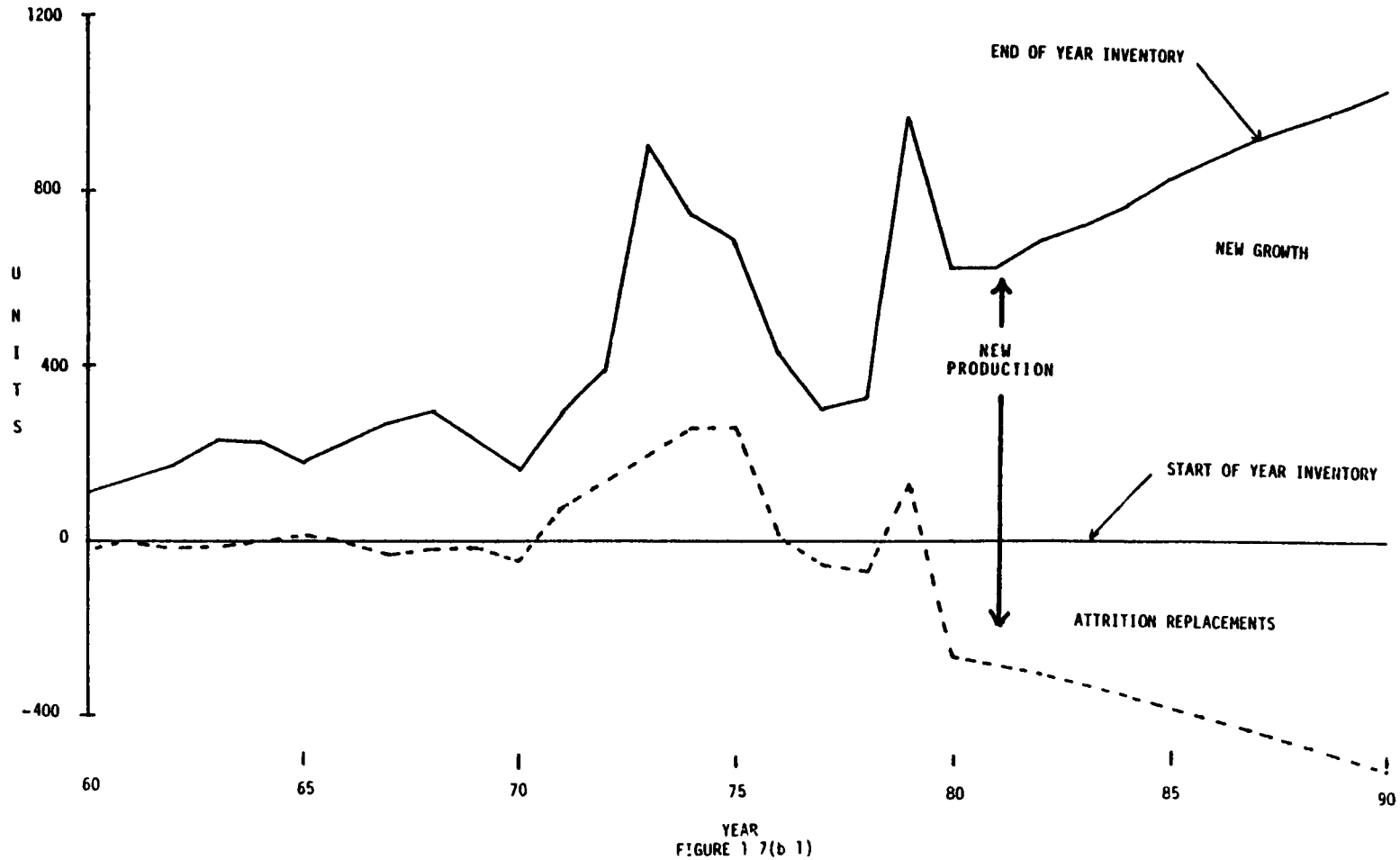

Figure 1.7(b 1). - U. S. civil rotorcraft new growth & replacement growth (units).

TABLE 1.7(c). - FREE WORLD CIVIL ROTORCRAFT NEW GROWTH & REPLACEMENT GROWTH

	60	61	62	63	64	65	66	67	68	69	70
START OF YEAR INVENTORY	1189	1411	1738	2118	2567	3049	3476	3890	4426	4991	5508
ATTRITION REPLACEMENT	-60	3	-10	1	-2	-6	-1	-28	4	33	63
NEW GROWTH	222	327	370	449	480	421	413	508	565	517	485
END OF YEAR INVENTORY	1411	1738	2118	2567	3049	3476	3890	4426	4991	5508	5993

	70	71	72	73	74	75	76	77	78	79	80
START OF YEAR INVENTORY	5508	5993	6612	7329	8567	9613	10512	11239	11917	12701	14120
ATTRITION REPLACEMENT	63	-61	-92	-198	-133	-38	75	81	53	-73	475
NEW GROWTH	485	558	625	1040	913	861	727	678	784	1346	1224
END OF YEAR INVENTORY	5993	6612	7329	8567	9613	10512	11239	11917	12701	14120	15344

	80	81	82	83	84	85	86	87	88	89	90
START OF YEAR INVENTORY	14120	15344	16679	18072	19561	21129	22793	24520	26336	28189	30121
ATTRITION REPLACEMENT	475	515	559	605	653	705	759	814	872	931	994
NEW GROWTH	1224	1335	1393	1489	1568	1664	1727	1815	1853	1932	2001
END OF YEAR INVENTORY	15344	16679	18072	19561	21129	22793	24520	26336	28189	30121	32122

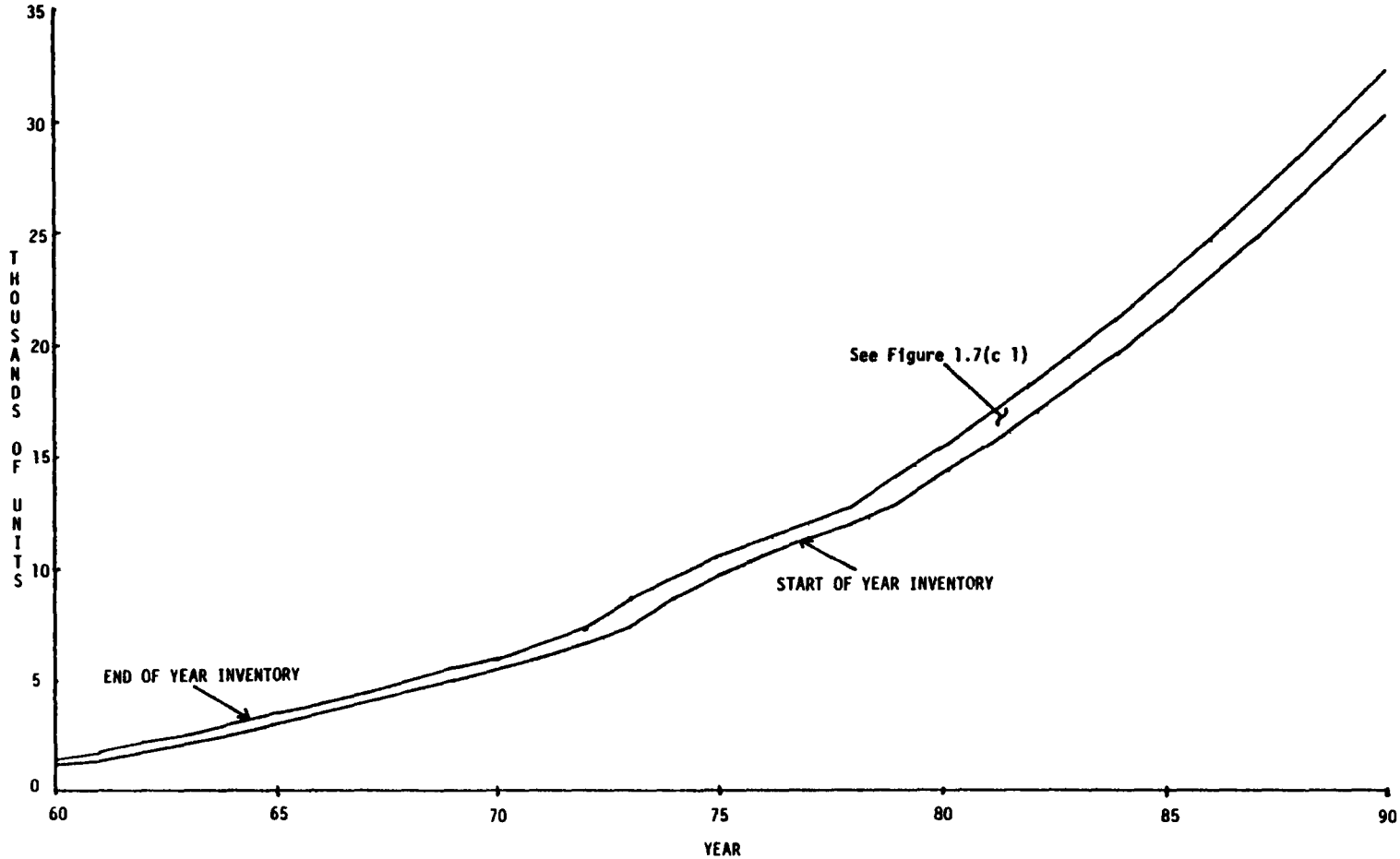

Figure 1.7(c). - Free world civil rotorcraft new growth & replacement growth (thousands of units).

TABLE 1.7(c 1). - FREE WORLD ROTORCRAFT RELATIONSHIP BETWEEN ATTRITION REPLACEMENT, USED MILITARY, AND ATTRITION

	60	61	62	63	64	65	66	67	68	69	70
ATTRITION REPLACEMENT	-60	3	-10	1	-2	-6	-1	-28	4	33	63
PLUS USED MILITARY	-	3	16	9	17	27	31	56	38	24	30
EQUALS ATTRITION	-	6	6	10	15	21	30	28	32	57	93

	70	71	72	73	74	75	76	77	78	79	80
ATTRITION REPLACEMENT	63	-61	-92	-198	-133	-38	75	81	53	-73	NA
PLUS USED MILITARY	30	110	129	161	263	192	93	73	143	150	NA
EQUALS ATTRITION	93	49	37	-37	130	154	168	154	196	77	NA

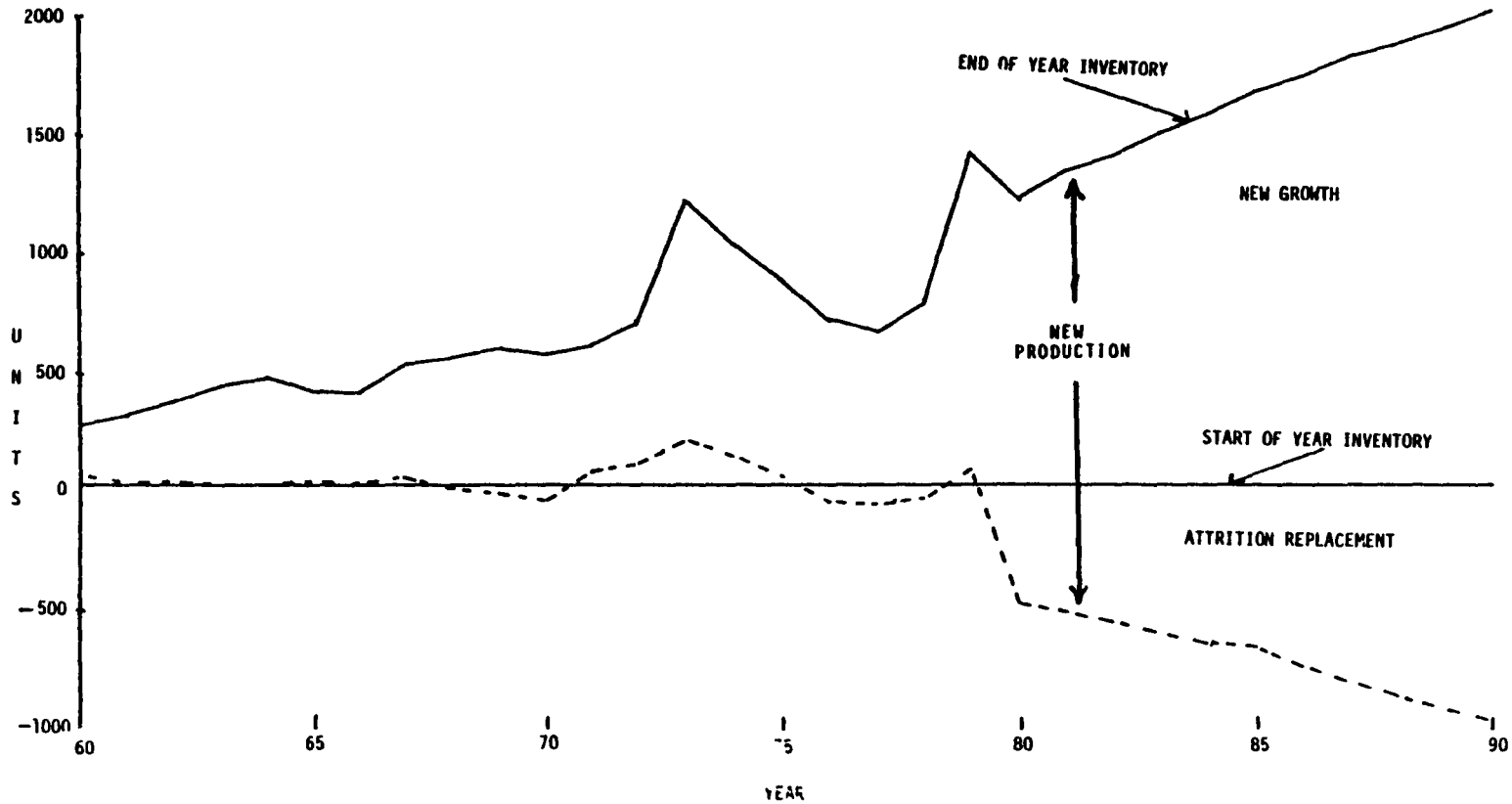

Figure 1.7(c 1). - Free world civil rotorcraft new growth and replacement growth (units).

TABLE 1.7(d). - U. S. MILITARY ROTORCRAFT NEW GROWTH & REPLACEMENT GROWTH

	60	61	62	63	64	65	66	67	68	69	70
START OF YEAR INVENTORY	-	3740	4045	4441	5075	5993	7063	8823	10509	11637	12561
ATTRITION REPLACEMENT	-	126	203	148	180	336	422	897	1344	1004	1472
NEW GROWTH	-	305	396	634	918	1070	1760	1685	1128	924	408
END OF YEAR INVENTORY	3740	4045	4441	5075	5993	7063	8823	10509	11637	12561	12969

	70	71	72	73	74	75	76	77	78	79	80
START OF YEAR INVENTORY	12561	12969	12416	12032	11612	11297	10760	10238	9680	9632	9499
ATTRITION REPLACEMENT	1472	1803	1421	1106	577	767	656	626	175	259	145
NEW GROWTH	408	-553	-384	-420	-315	-537	-522	-558	-48	-133	33
END OF YEAR INVENTORY	12969	12416	12032	11612	11297	10760	10238	9680	9632	9499	9532

	80	81	82	83	84	85	86	87	88	89	90
START OF YEAR INVENTORY	9499	9532	9494	9462	9445	9469	9560	9677	9783	9869	9999
ATTRITION REPLACEMENT	145	145	144	144	144	145	148	147	152	152	153
NEW GROWTH	33	-38	-32	-17	24	91	117	106	86	130	18
END OF YEAR INVENTORY	9532	9494	9462	9445	9469	9560	9677	9783	9869	9999	10017

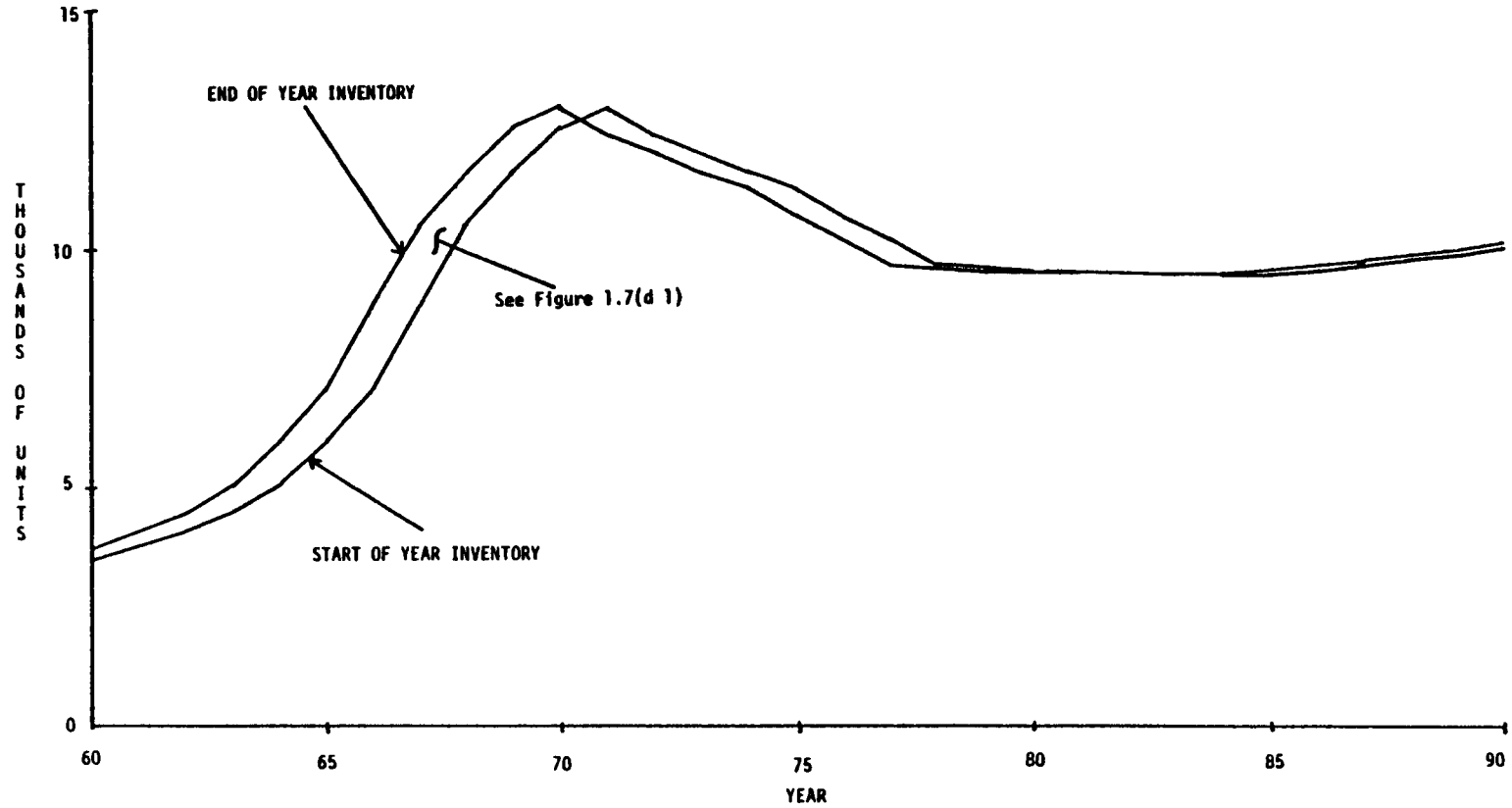

Figure 1.7(d). - U. S. military rotorcraft new growth & replacement growth (thousands of units).

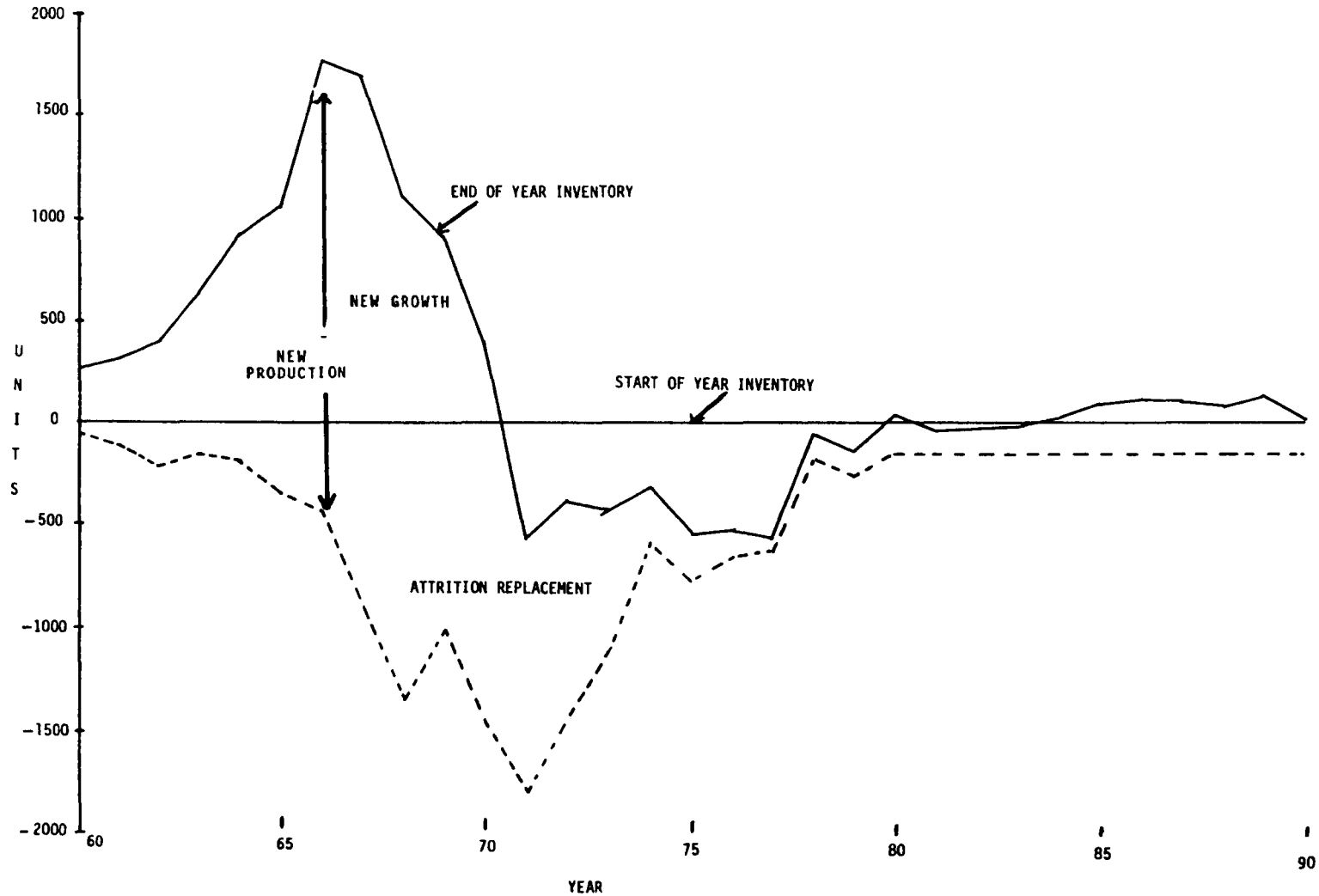

Figure 1.7(d 1). - U. S. military rotorcraft new growth & replacement growth (units).

TABLE 1.7(e). - FREE WORLD MILITARY ROTORCRAFT NEW GROWTH & REPLACEMENT GROWTH

	60	61	62	63	64	65	66	67	68	69	70
START OF YEAR INVENTORY	-	5739	6367	7273	8421	9738	11158	13346	15316	16971	18155
ATTRITION REPLACEMENT	-	132	242	172	241	402	544	1092	1440	1438	1649
NEW GROWTH	-	628	906	1148	1317	1420	2188	1970	1655	1184	963
END OF YEAR INVENTORY	5739	6367	7273	8421	9738	11158	13346	15316	16971	18155	19118

	70	71	72	73	74	75	76	77	78	79	80
START OF YEAR INVENTORY	18155	19118	19426	19669	19847	19760	19721	19729	19818	19892	20153
ATTRITION REPLACEMENT	1649	1501	1339	1185	1013	1102	892	733	706	389	312
NEW GROWTH	963	308	243	178	-87	-39	8	89	74	261	359
END OF YEAR INVENTORY	19118	19426	19669	19847	19760	19721	19729	19818	19892	20153	20512

	80	81	82	83	84	85	86	87	88	89	90
START OF YEAR INVENTORY	20153	20512	20844	21286	21538	21914	22492	23059	23592	24165	24757
ATTRITION REPLACEMENT	312	318	237	405	342	343	351	359	368	377	384
NEW GROWTH	359	332	442	252	376	578	567	533	573	592	473
END OF YEAR INVENTORY	20512	20844	21286	21538	21914	22492	23059	23592	24165	24757	25230

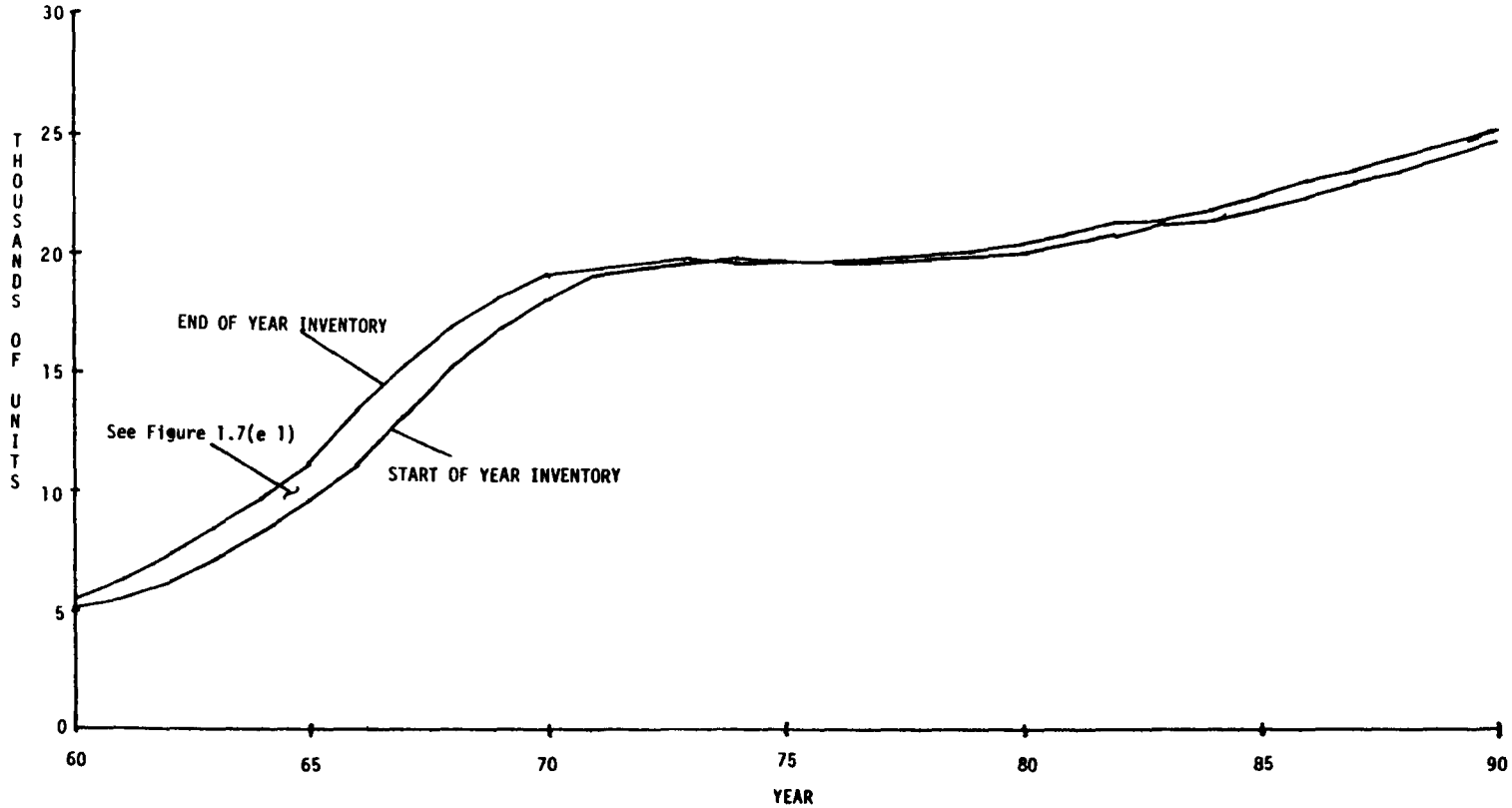

Figure 1.7(e). - Free world military rotorcraft new growth & replacement growth (thousands of units).

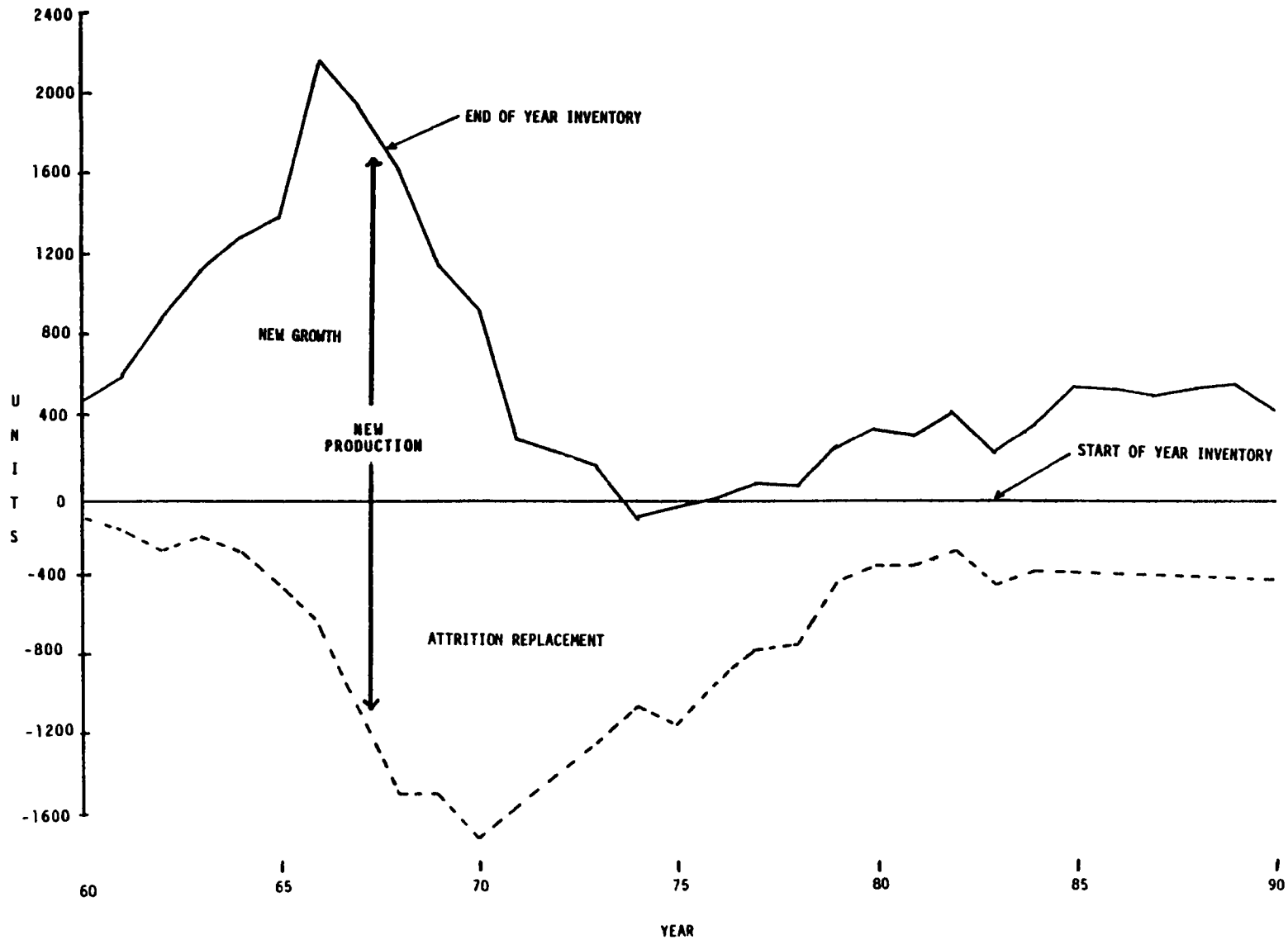

Figure 1.7(e 1). - Free world military rotorcraft new growth & replacement growth (units).

Task 1.8 - Penetration of rotorcraft markets in the U.S., Europe, and the rest of the world by foreign manufacturers.

U.S. Civil Rotorcraft Market (Tables/Figures 1.8 a & b) - The U.S. Civil Rotorcraft market was significantly penetrated by Aerospatiale of France beginning in 1979 with the introduction of the SA 350 "A Star," and the SA 365 "Twin Dauphin." This new production is being countered by expanded marketing of the Bell 206L-1, the Hughes 500D, and the Bell 222. The SA 355 "Twin A Star" is soon to be introduced. Given a strong commitment to advanced technology funding and application, U.S.-designed products can meet the challenge of foreign market penetration and sales would be expected to grow faster than European-designed products in the U.S. market.

TABLE 1.8(a). - U. S. CIVIL ROTORCRAFT MARKET (UNITS)

HISTORY											
	60	61	62	63	64	65	66	67	68	69	70
EUROPE DESIGN	1	1	0	0	0	0	4	2	1	11	27
U.S. DESIGN	95	141	164	229	229	164	224	234	281	236	183
TOTAL CIVIL	96	142	164	229	229	164	228	236	282	247	210

HISTORY											
	70	71	72	73	74	75	76	77	78	79	80
EUROPE DESIGN	27	21	7	53	60	29	42	42	44	133	189
U.S. DESIGN	183	195	257	506	429	396	362	310	348	702	698
TOTAL CIVIL	210	216	264	559	489	425	404	352	392	835	887

FORECAST											
	80	81	82	83	84	85	86	87	88	89	90
EUROPE DESIGN	189	220	218	229	249	262	251	264	275	268	301
U.S. DESIGN	698	690	775	820	870	947	1026	1089	1137	1193	1254
TOTAL CIVIL	887	910	993	1049	1119	1209	1277	1353	1412	1481	1555

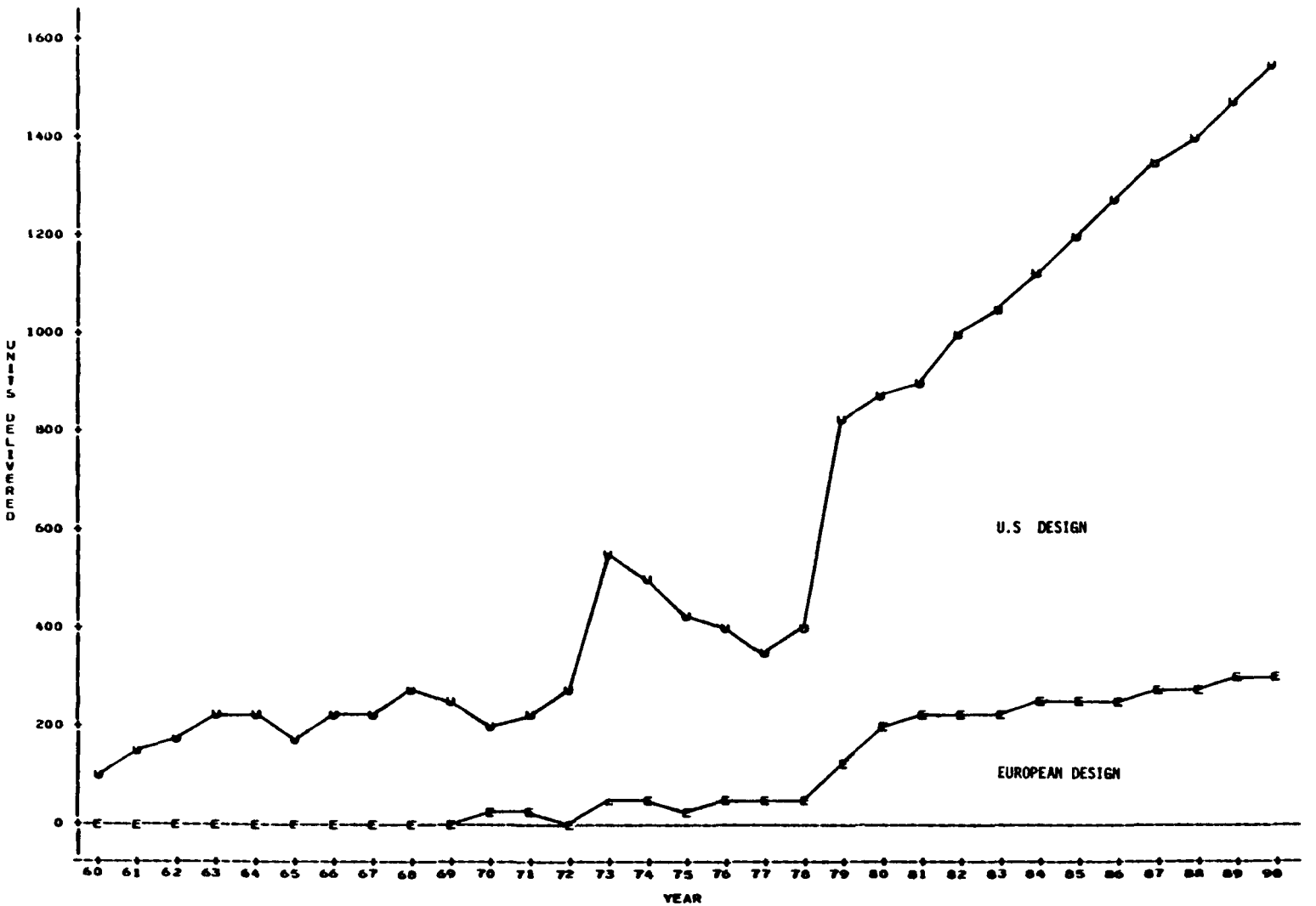

Figure 1.8(a). - U. S. civil rotorcraft market (units).

TABLE 1.8(b). - U. S. CIVIL ROTORCRAFT MARKET ($ MILLIONS)

	60	61	62	63	64	65	66	67	68	69	70
HISTORY											
EUROPE DESIGN	0	0	0	0	0	0	0	0	0	2	4
U.S. DESIGN	6	7	15	18	14	16	18	24	46	40	21
TOTAL CIVIL	7	7	15	18	14	16	18	24	46	42	24

	70	71	72	73	74	75	76	77	78	79	80
HISTORY											
EUROPE DESIGN	4	3	1	12	13	7	11	30	32	65	94
U.S. DESIGN	21	24	34	80	80	98	89	78	89	203	305
TOTAL CIVIL	24	27	36	92	94	105	100	107	121	267	399

	80	81	82	83	84	85	86	87	88	89	90
FORECAST											
EUROPE DESIGN	94	139	146	170	205	248	236	278	318	369	435
U.S. DESIGN	305	426	569	641	660	761	889	1022	1117	1292	1469
TOTAL CIVIL	399	565	715	811	865	1009	1125	1300	1435	1661	1904

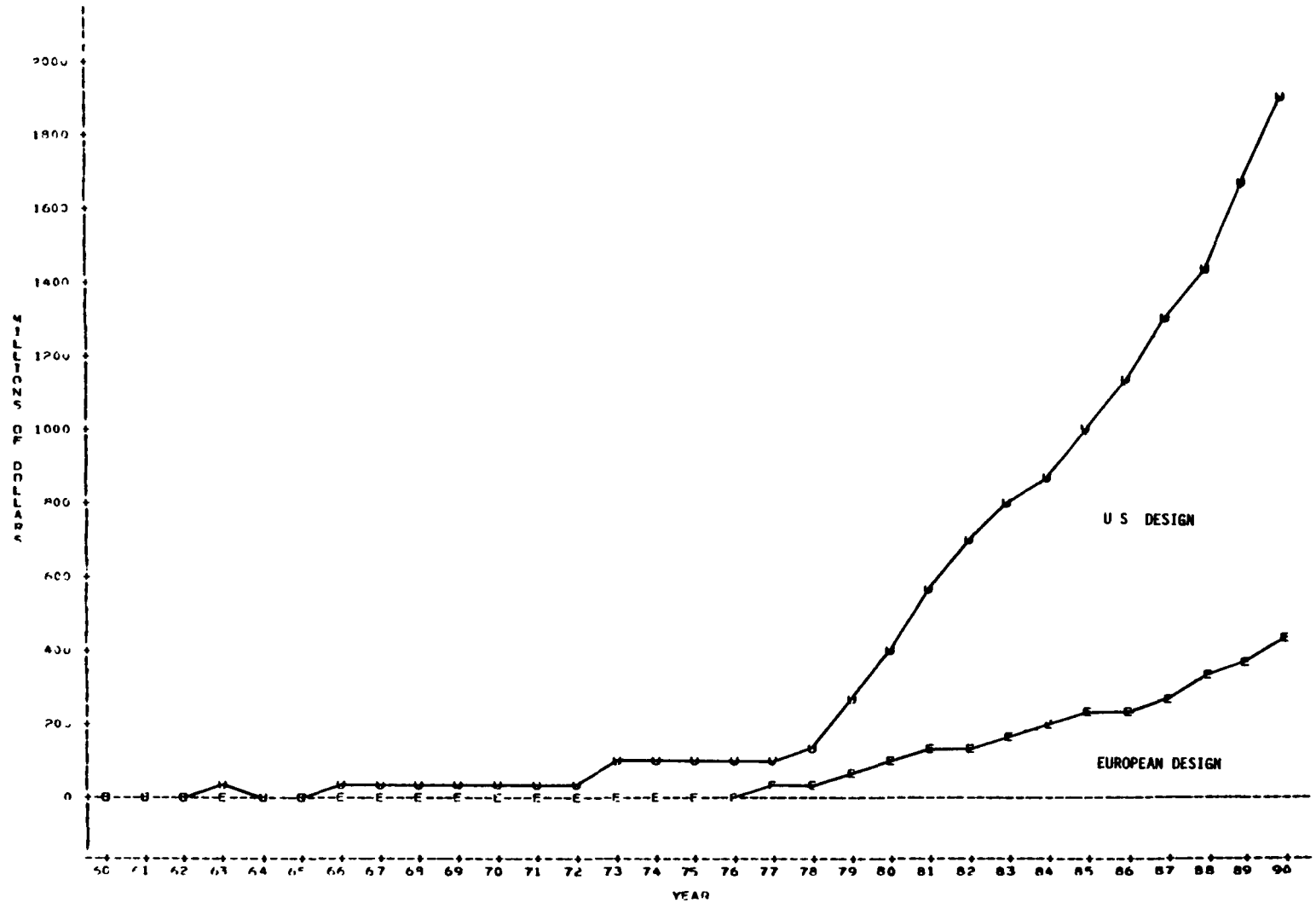

Figure 1.8(b). - U. S. civil rotorcraft market ($ millions).

European Civil Rotorcraft Market (Tables/Figures 1.8 c & d)

The European civil rotorcraft market was significantly affected beginning in 1977 with the introduction of the SA 350 and SA 365. The European-designed helicopters increased their share from 22 percent in 1976 to 40 percent in 1979. This ratio can be expected to gradually recede to 22 percent again at the end of the forecast period as U.S. productivity is reestablished and the U.S. advanced state of technology is accelerated and implemented.

TABLE 1.8(c). - EUROPEAN CIVIL ROTORCRAFT MARKET (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
EUROPE DESIGN	1	5	10	12	10	9	2	7	8	12	9
U.S. DESIGN	12	17	29	54	46	59	38	58	89	84	75
TOTAL CIVIL	13	22	39	66	56	68	40	65	97	96	84

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
EUROPE DESIGN	9	28	34	40	50	28	22	30	51	58	86
U.S. DESIGN	75	64	93	130	95	113	77	77	94	85	142
TOTAL CIVIL	84	92	127	170	145	141	99	107	145	143	228

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
EUROPE DESIGN	86	81	93	100	100	110	112	116	123	125	129
U.S. DESIGN	142	155	163	171	190	191	213	238	319	367	442
TOTAL CIVIL	228	236	256	271	290	301	325	354	442	492	571

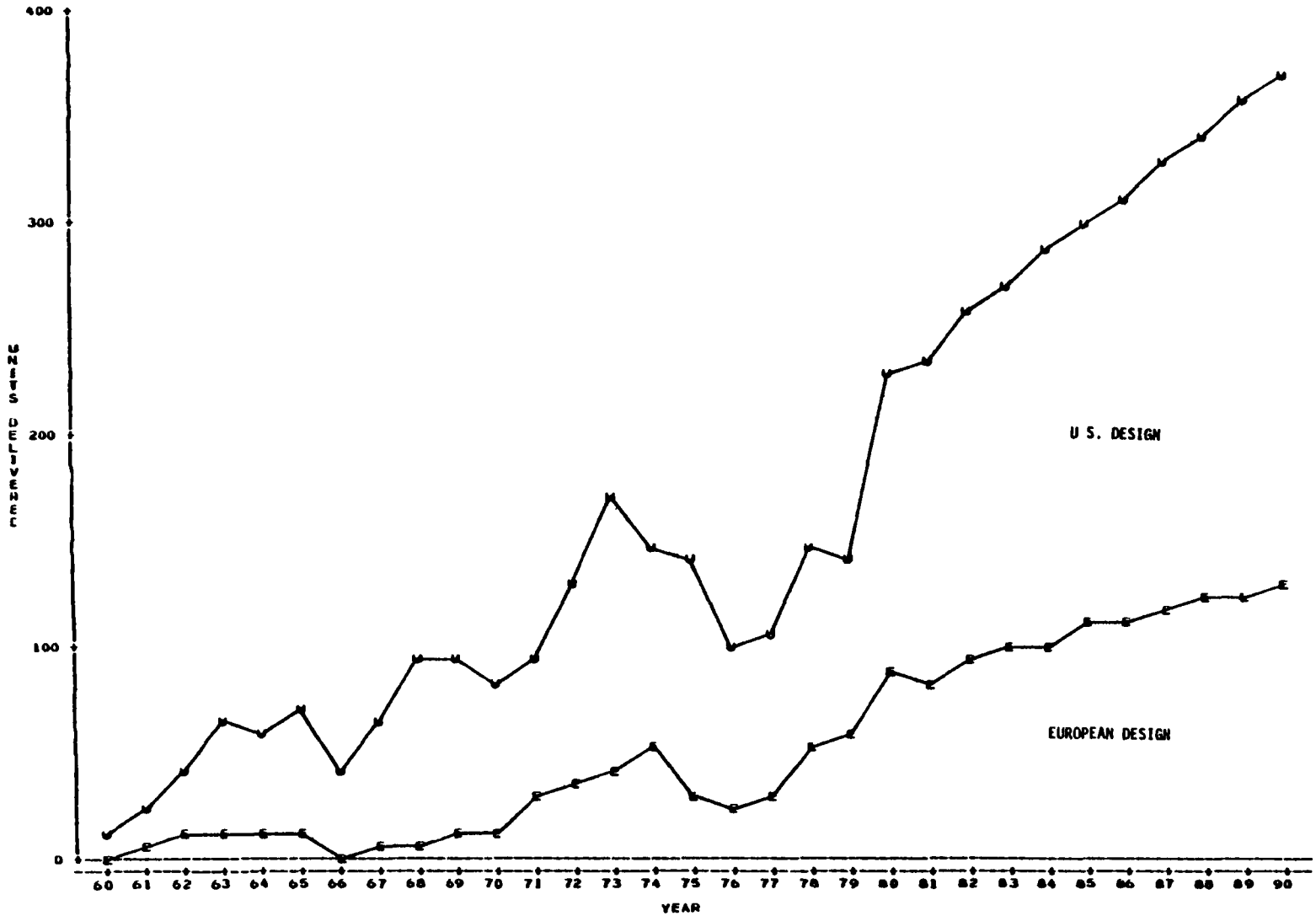

Figure 1.8(c). - European civil rotorcraft market (units).

TABLE 1.8(d). - EUROPEAN CIVIL ROTORCRAFT MARKET ($ MILLIONS)

	60	61	62	63	64	65	66	67	68	69	70
HISTORY											
EUROPE DESIGN	0	1	1	1	1	1	0	1	1	2	2
U.S. DESIGN	1	1	2	5	7	7	6	5	12	14	10
TOTAL CIVIL	1	2	3	6	8	8	7	6	13	16	12

	70	71	72	73	74	75	76	77	78	79	80
HISTORY											
EUROPE DESIGN	2	4	6	14	19	15	13	26	56	54	64
U.S. DESIGN	10	14	21	29	44	51	32	40	56	48	62
TOTAL CIVIL	12	18	28	43	64	66	45	66	112	102	126

	80	81	82	83	84	85	86	87	88	89	90
FORECAST											
EUROPE DESIGN	64	72	93	109	122	141	160	177	209	235	262
U.S. DESIGN	62	73	117	121	197	213	238	319	367	442	496
TOTAL CIVIL	126	145	210	230	319	354	398	496	576	677	766

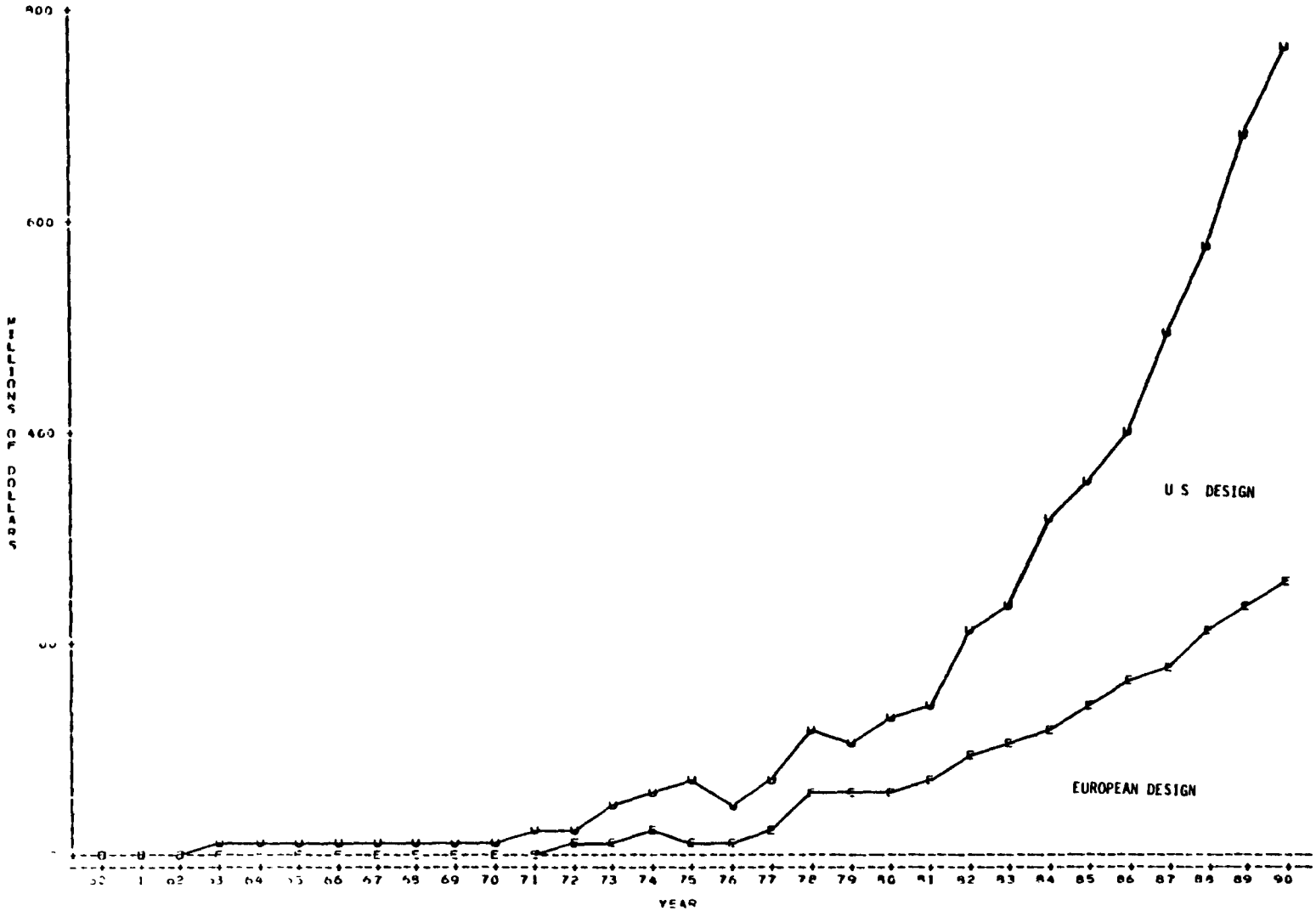

Figure 1.8(d). - European civil rotorcraft market ($ millions).

Foreign (Less Europe) Civil Rotorcraft Market (Tables/Figures 1.8 e & f) - As in the U.S., the introduction of the SA 350 and 365 made an initial penetration of foreign (less Europe) civil rotorcraft market. Again drawing from an accelerated technology data base and expanded marketing of U.S. products the market share won by European's designs can be reclaimed.

TABLE 1.8(e). - FOREIGN FREE WORLD (LESS EUROPE) CIVIL ROTORCRAFT MARKET (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
EUROPE DESIGN	2	2	6	3	7	15	1	7	8	20	26
U.S. DESIGN	111	164	161	152	188	174	144	200	182	187	228
TOTAL CIVIL	113	166	167	155	195	189	145	207	190	207	254

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
EUROPE DESIGN	26	53	41	50	39	49	39	55	56	72	148
U.S. DESIGN	228	197	193	261	240	246	260	245	244	296	436
TOTAL CIVIL	254	250	234	311	279	295	299	300	300	368	584

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
EUROPE DESIGN	148	154	166	180	176	184	197	201	201	206	211
U.S. DESIGN	436	551	537	594	636	675	701	748	768	818	859
TOTAL CIVIL	584	705	703	774	812	859	898	949	969	1024	1070

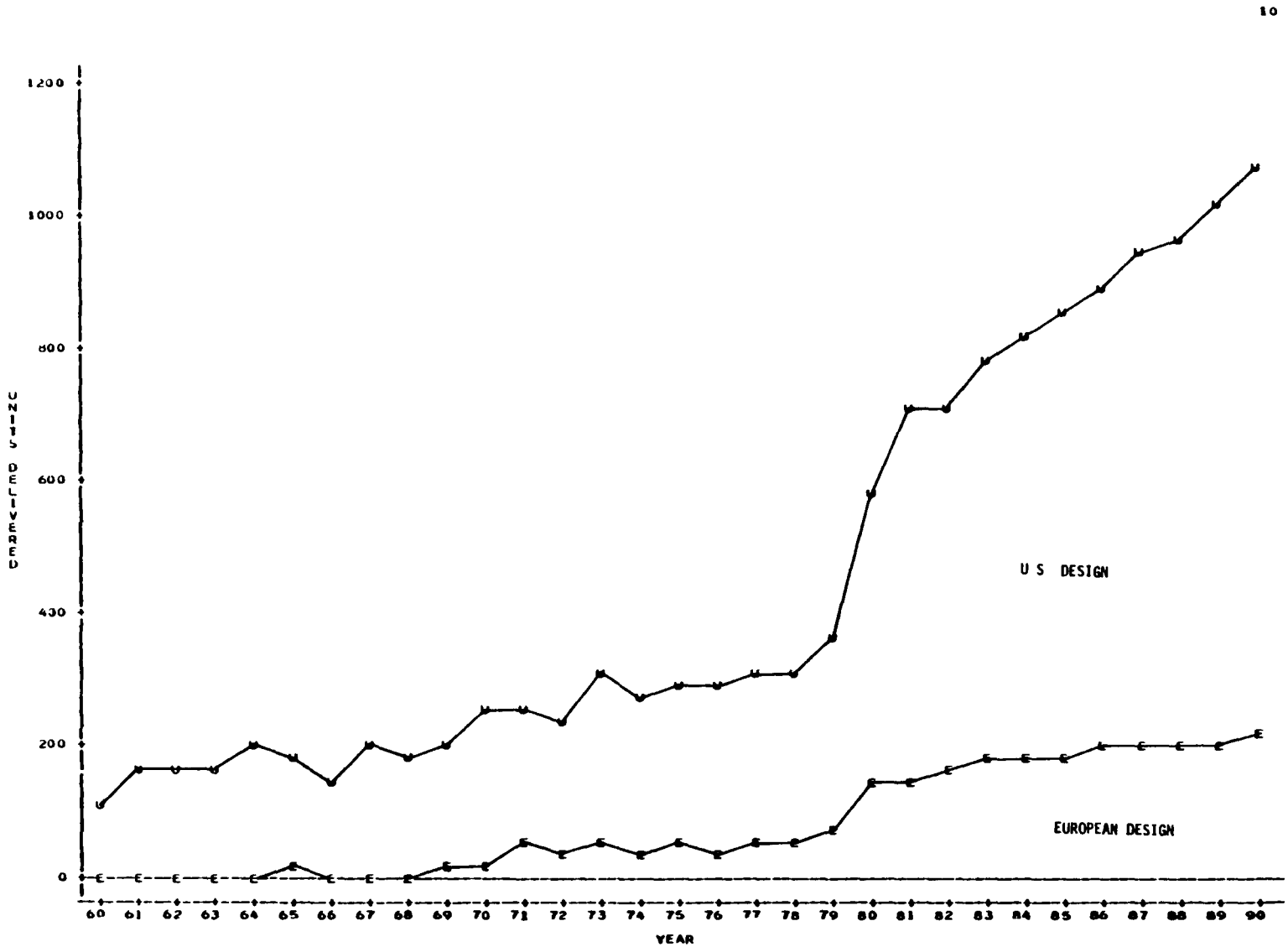

Figure 1.8(e). - Foreign free world (less Europe) civil rotorcraft market (units).

TABLE 1.8(f). - FOREIGN FREE WORLD (LESS EUROPE) CIVIL ROTORCRAFT MARKET ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
EUROPE DESIGN	0	0	1	0	2	2	0	1	1	4	5
U.S. DESIGN	7	10	10	12	12	14	10	22	18	31	26
TOTAL CIVIL	7	10	11	12	13	16	10	23	19	35	31

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
EUROPE DESIGN	5	11	10	15	22	20	15	40	52	50	87
U.S. DESIGN	26	32	37	49	53	69	78	76	80	127	196
TOTAL CIVIL	31	43	48	64	75	89	93	115	132	177	283

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
EUROPE DESIGN	87	105	119	151	153	177	218	238	260	292	317
U.S. DESIGN	196	258	276	368	457	531	596	706	832	985	1162
TOTAL CIVIL	283	363	395	519	610	708	814	944	1092	1277	1479

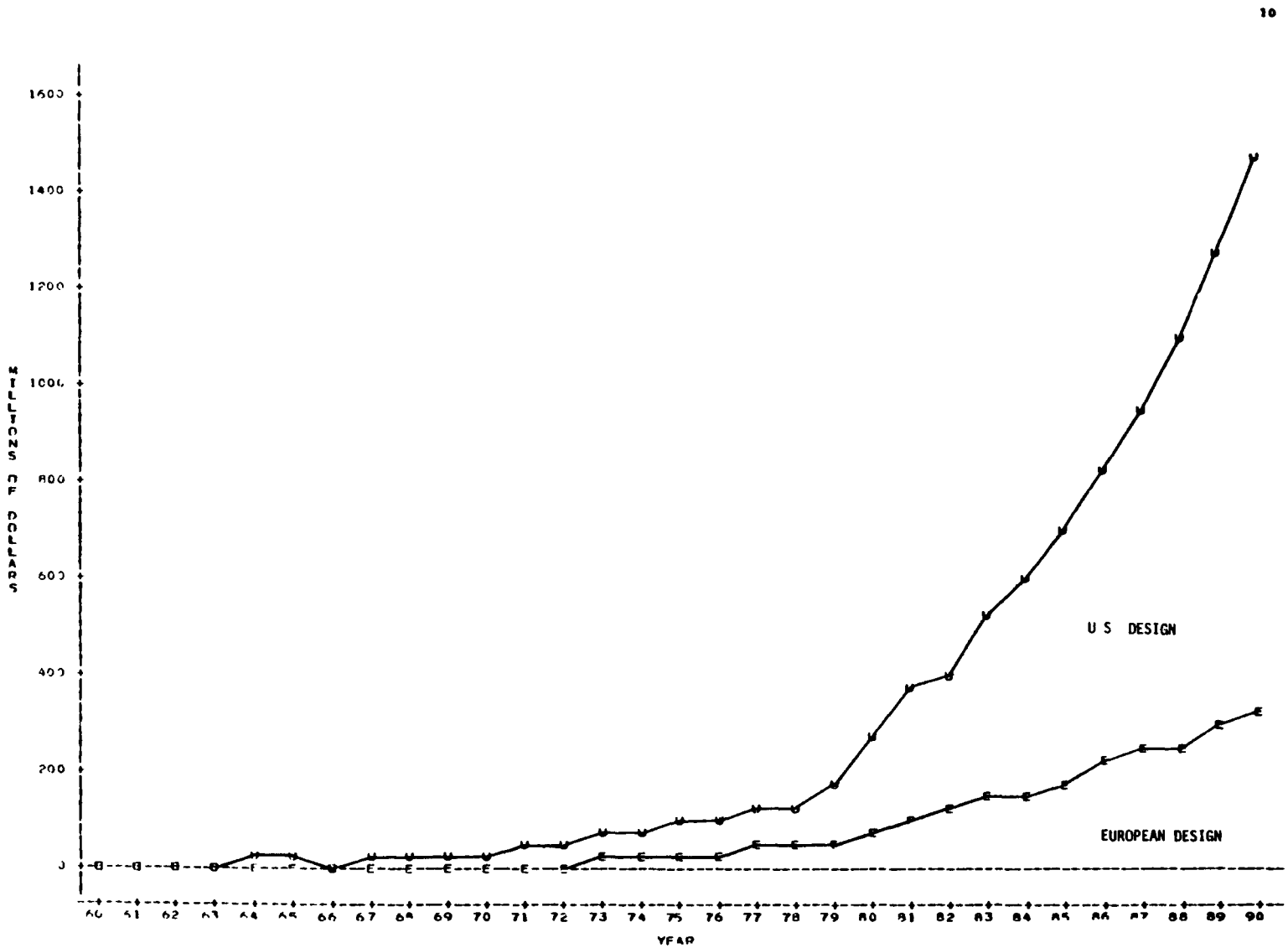

Figure 1.8(f). - Foreign free world (less Europe) civil rotorcraft market ($ millions).

U.S. Military Rotorcraft Market (Tables/Figures I.8 g & h)
There are no European-designed helicopters that have been procured by the U.S. military, nor are there expected to be any. (The Coast Guard buy of the AS 365N is considered a part of the civil market.)

TABLE 1.8(g). - U. S. MILITARY ROTORCRAFT MARKET (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
EUROPE DESIGN	0	0	0	0	0	0	0	0	0	0	0
U.S. DESIGN	500	431	599	782	1098	1406	2182	2583	2472	1928	1880
TOTAL MILITARY	500	431	599	782	1098	1406	2182	2583	2472	1928	1880

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
EUROPE DESIGN	0	2	0	0	0	0	0	0	0	0	0
U.S. DESIGN	1880	1248	1037	686	202	230	134	88	127	126	177
TOTAL MILITARY	1880	1250	1037	686	202	230	134	88	127	126	177

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
EUROPE DESIGN	0	0	0	0	0	0	0	0	0	0	0
U.S. DESIGN	177	106	110	126	178	237	265	253	238	282	171
TOTAL MILITARY	177	106	110	126	178	237	265	253	238	282	171

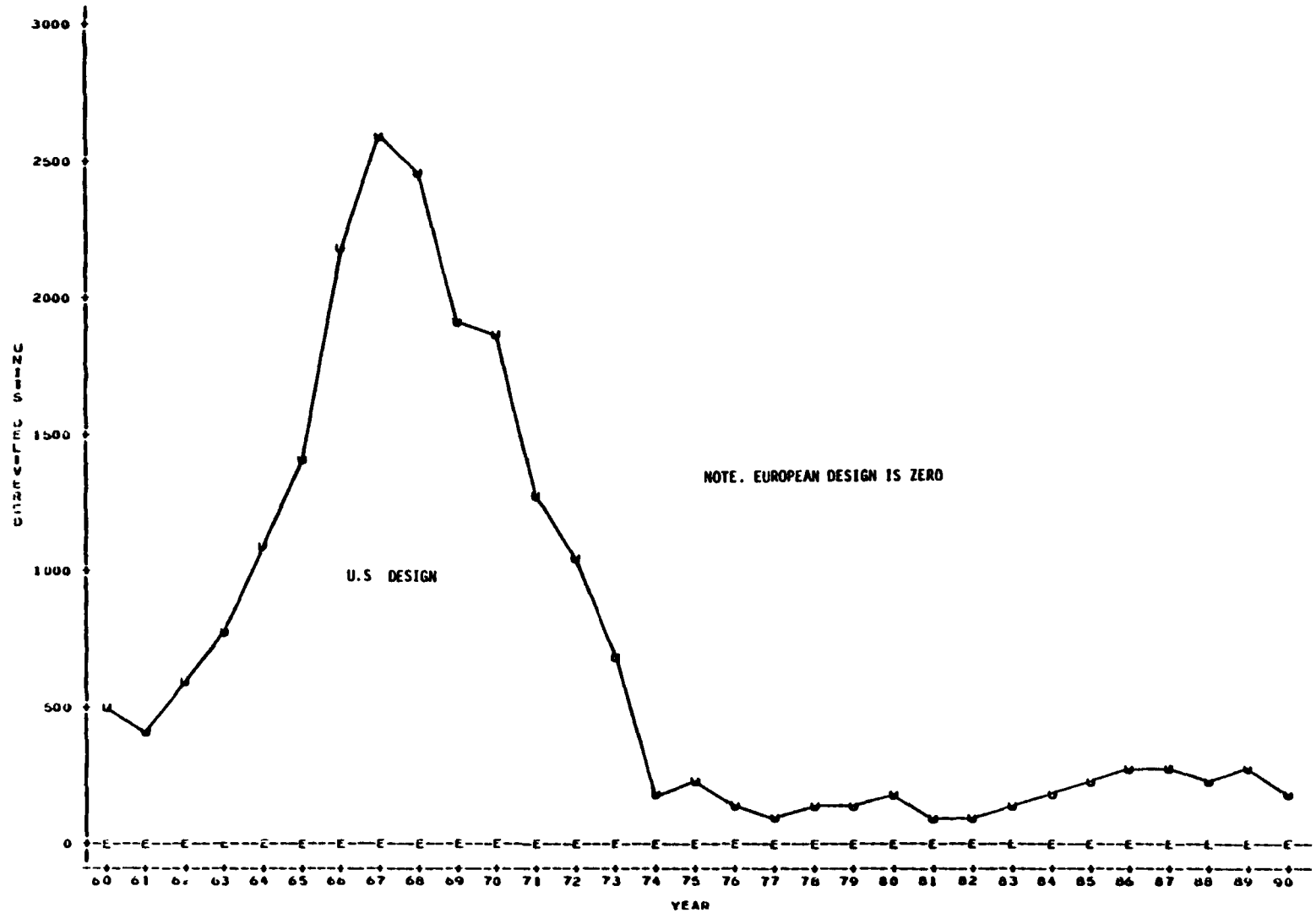

Figure 1.8(g). - U. S. military rotorcraft market (units).

TABLE 1.8(h). - U. S. MILITARY ROTORCRAFT MARKET ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
EUROPE DESIGN	0	0	0	0	0	0	0	0	0	0	0
U.S. DESIGN	89	120	182	243	323	498	798	1057	1494	1205	1140
TOTAL MILITARY	89	120	182	243	323	498	798	1057	1494	1205	1140

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
EUROPE DESIGN	0	0	0	0	0	0	0	0	0	0	0
U.S. DESIGN	1140	646	422	231	179	219	166	117	169	202	391
TOTAL MILITARY	1140	646	422	231	179	219	166	117	169	202	391

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
EUROPE DESIGN	0	0	0	0	0	0	0	0	0	0	0
U.S. DESIGN	391	304	346	699	1457	1953	2236	2398	2502	2938	2141
TOTAL MILITARY	391	304	346	699	1457	1953	2236	2398	2502	2938	2141

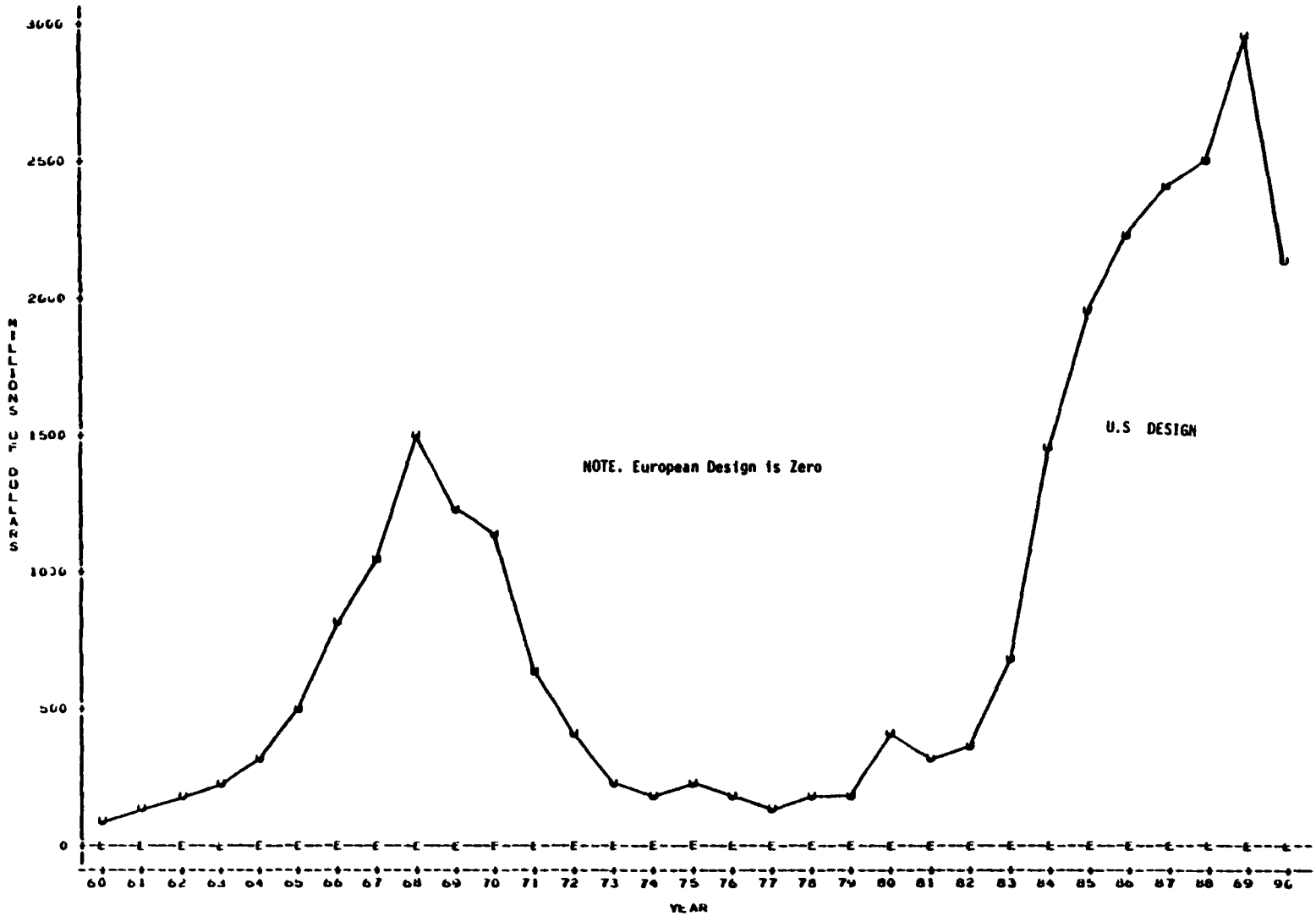

Figure 1.8(h). - U. S. military rotorcraft market ($ millions).

European Military Rotorcraft Market (Tables/Figures 1.8 1 & 1)
The European rotorcraft market, as expected with military procurement, oscillates considerably; however, overall,it is expected to remain between 200 and 400 units per year. The European-designed helicopters are expected to substantially increase their share of this market during the forecast period. U.K. and German forces, using home industry, will be a major factor in this gain.

TABLE 1.8(i). - EUROPEAN MILITARY ROTORCRAFT MARKET (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
EUROPE DESIGN	225	104	212	191	88	55	124	69	40	73	209
U.S. DESIGN	102	123	181	214	176	189	198	225	241	206	177
TOTAL MILITARY	327	227	393	405	264	244	322	294	281	279	386

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
EUROPE DESIGN	209	194	62	75	128	179	144	131	80	159	144
U.S. DESIGN	177	110	139	155	131	71	75	67	94	58	104
TOTAL MILITARY	386	304	201	230	259	250	219	198	174	217	248

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
EUROPE DESIGN	144	226	228	206	186	292	289	266	266	248	229
U.S. DESIGN	104	84	56	59	63	61	59	71	68	82	85
TOTAL MILITARY	248	310	284	265	249	353	348	337	334	330	314

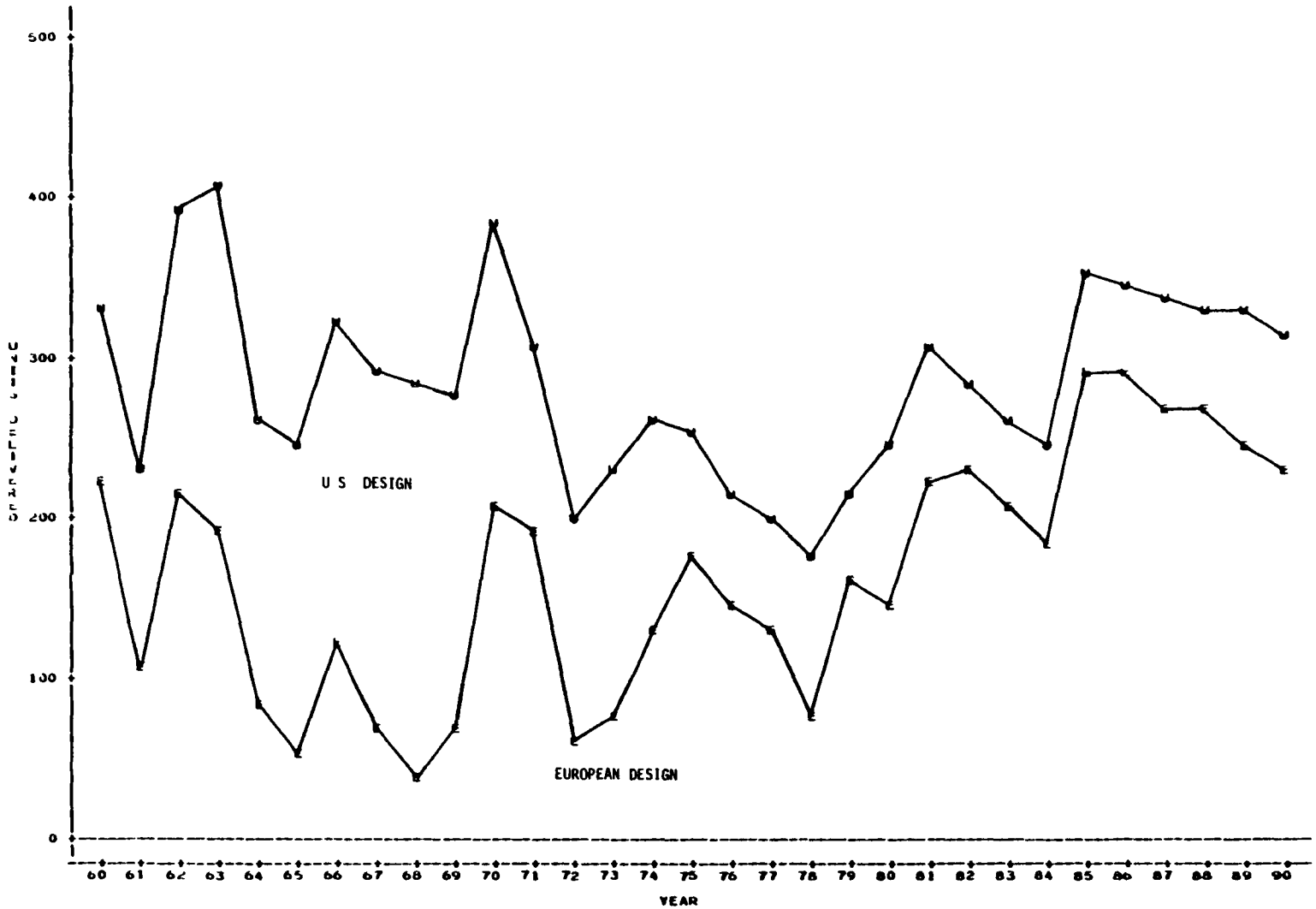

Figure 1.8(i). - European military rotorcraft market (units).

TABLE 1.8(j). - EUROPEAN MILITARY ROTORCRAFT MARKET ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
EUROPE DESIGN	81	11	30	29	16	10	27	16	36	29	113
U.S. DESIGN	14	16	28	57	62	57	56	46	60	56	70
TOTAL MILITARY	95	27	58	86	78	67	83	61	96	85	184

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
EUROPE DESIGN	113	102	54	29	55	101	67	103	300	471	377
U.S. DESIGN	70	90	110	192	164	116	113	65	114	46	215
TOTAL MILITARY	184	193	163	221	219	218	180	168	413	517	592

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
EUROPE DESIGN	377	525	572	533	547	991	1166	1376	1469	1606	1526
U.S. DESIGN	215	222	92	72	115	141	176	201	237	345	448
TOTAL MILITARY	592	747	664	605	662	1132	1342	1577	1706	1951	1974

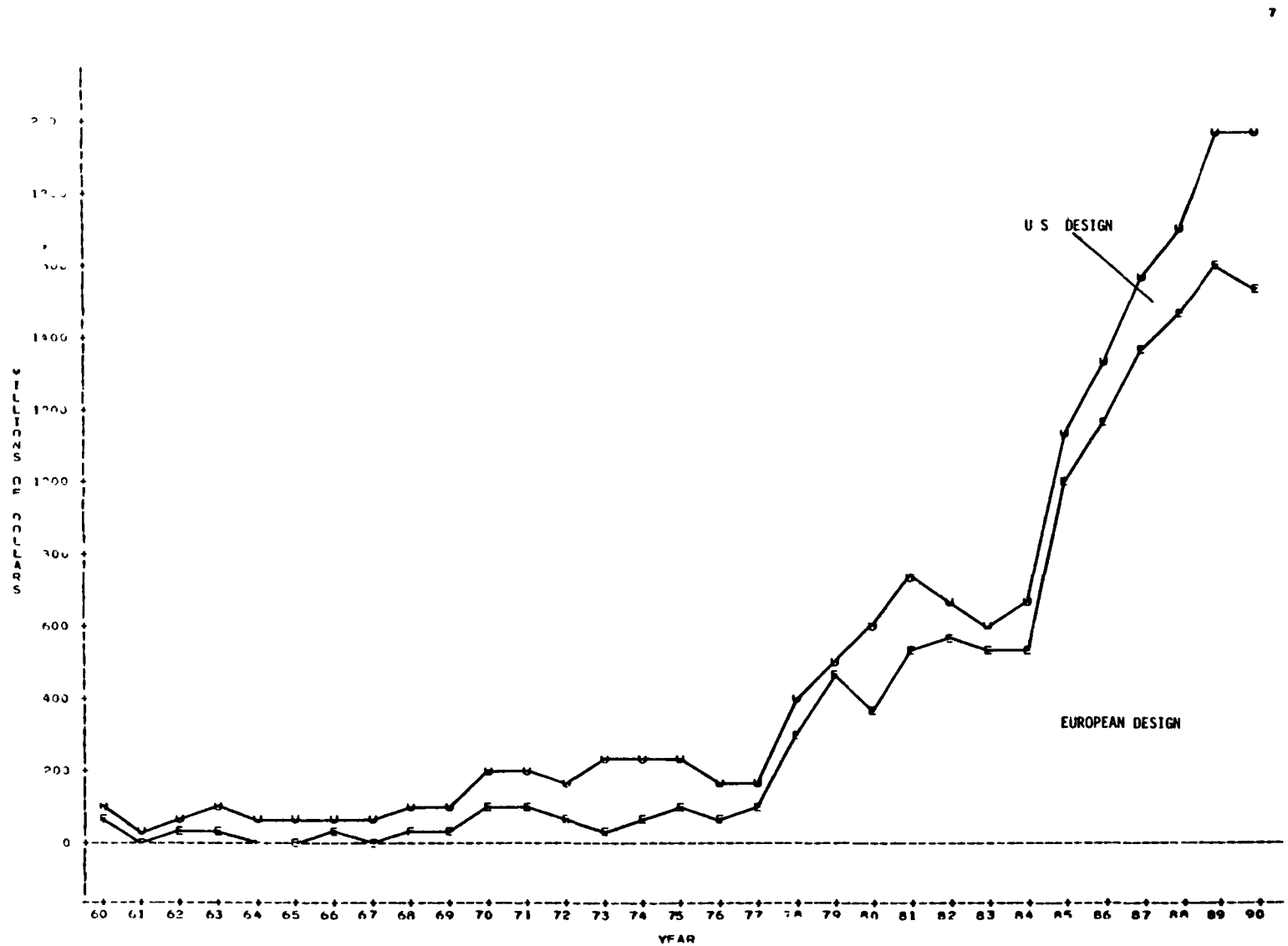

Figure 1.8(j). - European military rotorcraft market ($ millions).

Foreign (Less Europe) Military Rotorcraft Market (Tables/ Figures 1.8 k & l) - The foreign market (less Europe) is expected to climb during the forecast period with the European design share increasing from 22 percent in 1979 to 40 percent during the forecast period. This reflects foreign governments increasing apprehension of being dependent upon the U.S. as a source of supply in the face of fluctuating U.S. foreign policy.

TABLE 1.8(k). - FOREIGN FREE WORLD (LESS EUROPE) MILITARY ROTORCRAFT MARKET (UNITS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
EUROPE DESIGN	66	27	42	47	50	47	54	33	84	100	154
U.S. DESIGN	77	75	114	86	146	125	174	152	258	315	192
TOTAL MILITARY	143	102	156	133	196	172	228	185	342	415	346

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
EUROPE DESIGN	154	83	63	217	150	145	160	168	227	131	54
U.S. DESIGN	192	172	281	230	315	438	387	368	252	176	192
TOTAL MILITARY	346	255	344	447	465	583	547	536	479	307	246

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
EUROPE DESIGN	54	71	95	98	114	112	129	129	148	143	148
U.S. DESIGN	192	163	190	168	177	219	176	173	221	214	224
TOTAL MILITARY	246	234	285	266	291	331	305	302	369	357	372

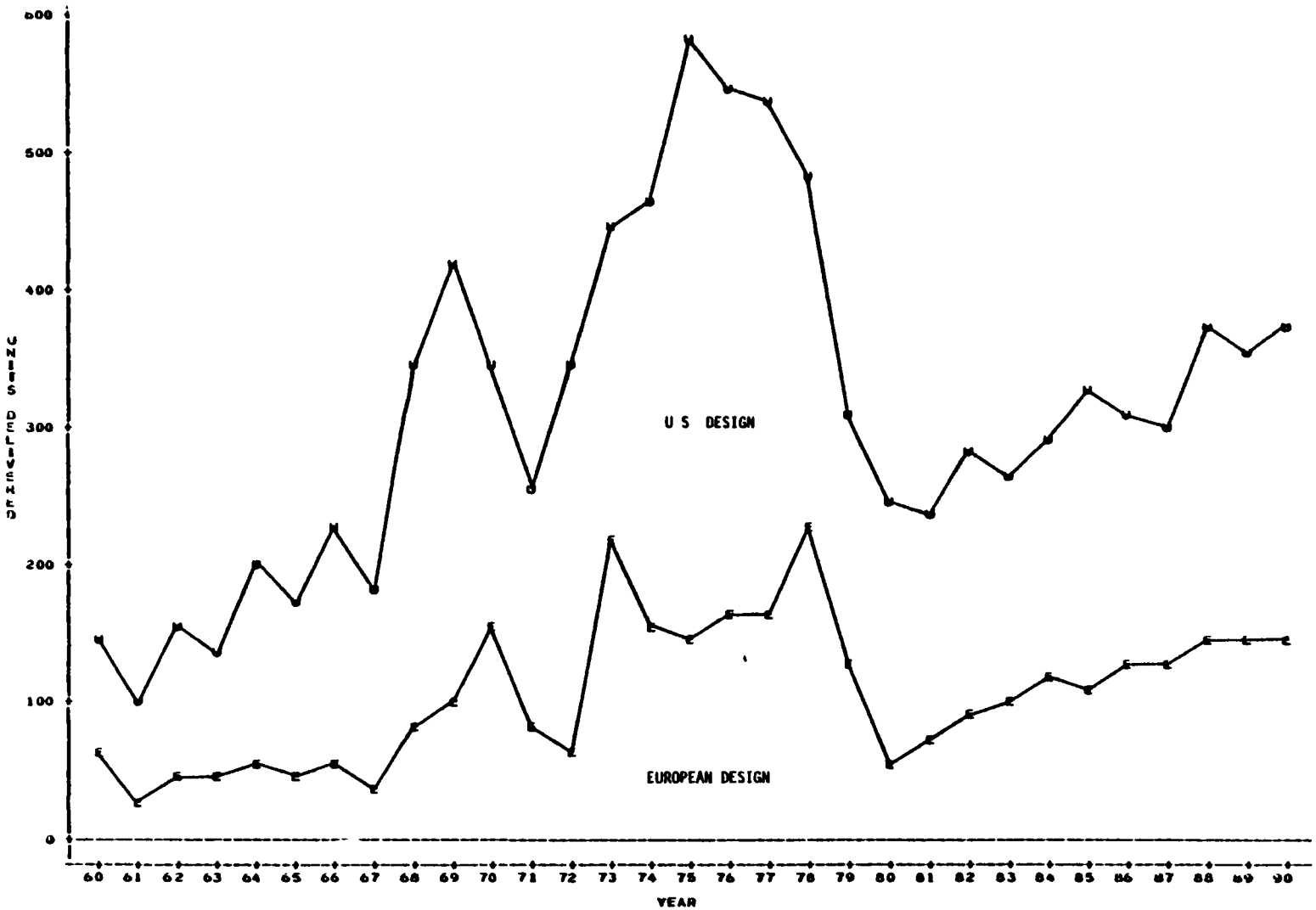

Figure 1.8(k). - Foreign free world (less Europe) military rotorcraft market (units).

TABLE 1.8(1). - FOREIGN FREE WORLD (LESS EUROPE) MILITARY ROTORCRAFT MARKET ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
EUROPE DESIGN	13	49	8	9	9	9	14	7	133	85	173
U.S. DESIGN	10	11	14	36	62	46	77	83	124	144	86
TOTAL MILITARY	23	60	21	45	71	57	92	90	257	229	260

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
EUROPE DESIGN	173	71	51	264	160	227	209	179	231	428	74
U.S. DESIGN	86	99	143	129	269	412	453	473	255	311	194
TOTAL MILITARY	260	170	194	392	429	640	662	652	486	739	268

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
EUROPE DESIGN	74	170	283	332	406	453	545	618	767	833	953
U.S. DESIGN	194	316	276	311	450	578	459	570	790	864	1020
TOTAL MILITARY	268	486	559	643	856	1031	1004	1188	1557	1697	1973

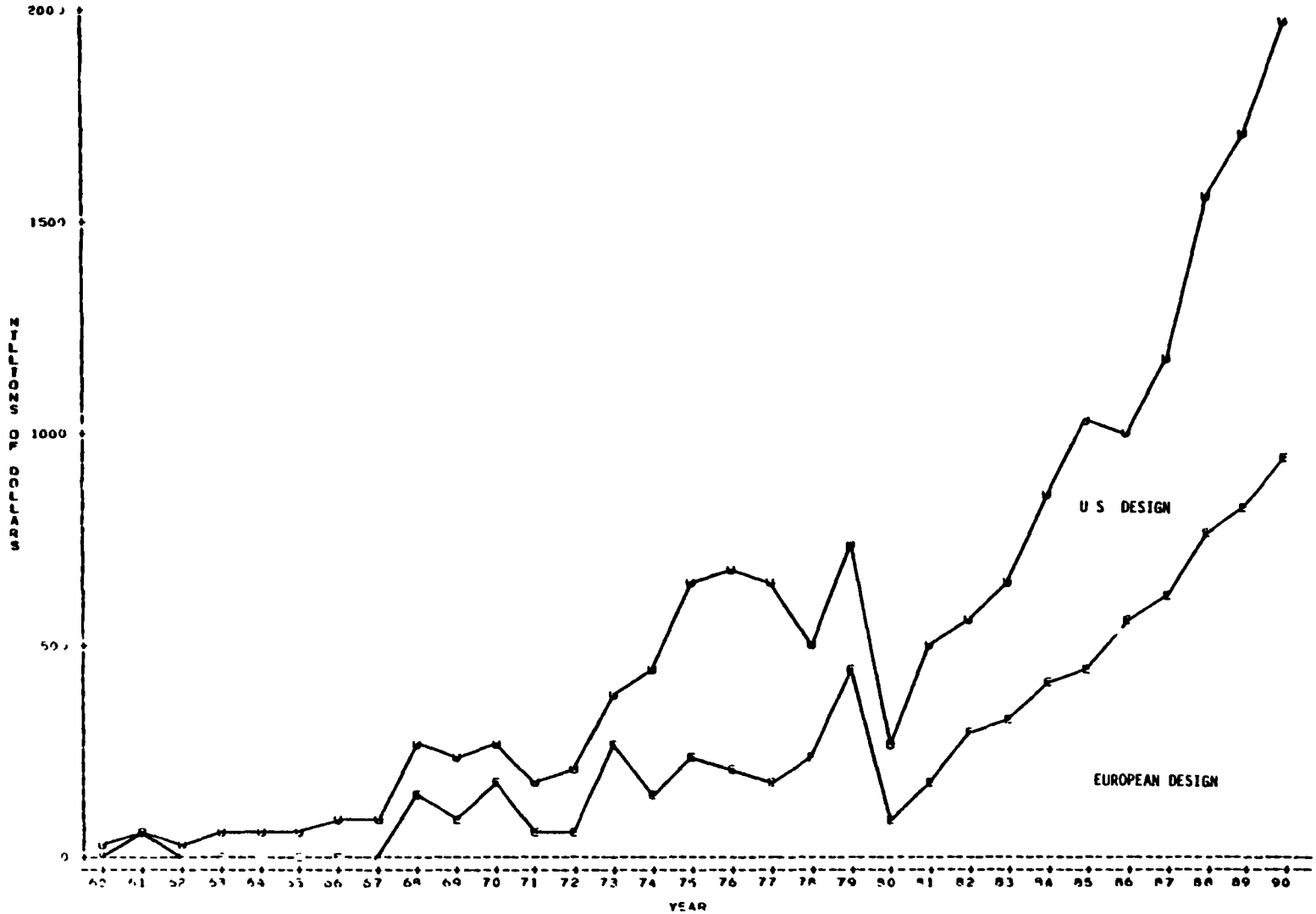

Figure 1.8(1). - Foreign free world (less Europe) military rotorcraft market ($ millions).

Task 1.9 - Government support in equivalent U.S. dollars and percent of national budget for the major free world nations involved in helicopter research and development (U.S./France/Great Britain/Germany/Italy/Japan) for the period 1960 through 1990. The value and impact of government support and consortium agreements on rotorcraft growth/products will be discussed.

Government Support of Rotorcraft R&D - The historical and forecast data for U.S. government support of helicopter research and development has been readily provided and is reflected in Tables/Figures 1.9(a) through 1.9(d).

Despite extensive searches and inquiries for funding data from various worldwide governments, institutional and private organizations, publications, and individuals, we have not been able to obtain meaningful data on foreign government expenditures except from France for the period 1970 through 1975. Aerospatiale has also estimated the total European government investment in helicopter research and development for the period 1970 through 1975.

No breakdown has been given for either France or for Europe as a whole between civil and military research and development, nor is it believed meaningful. In the United Kingdom, France, and Italy, the rotorcraft industry has been nationalized, and in the case of Germany, heavily subsidized through sole source procurement. In all European countries, because the individual national requirement will not support development of a specialized aircraft, the end products are tailored to meet multinational requirements for both civil and military aircraft.

In fact, the research and development figures that were supplied by Aerospatiale for France and estimated for Europe are suspect. The industries are heavily subsidized and the difference between government funded research and development and that funded by industry is virtually indistinguishable.

For the purpose of the Tables/Figures 1.9(a) through 1.9(d), the French research and development funds have been subtracted from the European estimate, leaving the U.K., French, and Italian industry rolled together. In both cases, the total funds have been arbitrarily divided 50/50 between civil and military.

Indications are that the Japanese government has not, up to the present time, supplied any identifiable research and development funds to helicopter manufacturers. Funds that may have been supplied to national organizations such as the National Research Institute are of unknown nature but are not

believed significant. It is reported that the Japan Development Bank has financed a manufacturer for the development of a helicopter -- presumably Kawasaki for the BK-117 -- but confirmation of this is lacking.

It is to be noted from Tables and Figure 1.9(c) that military research and development government funding took a substantial jump in the mid-1960's of about six-fold, then steadily increased until the end of the 1970's. Current projections indicate that the support will fall off rapidly in the early 1980's, then resume an upward trend. The U.S. civil government funding (Table and Figure 1.9(a)) prior to the mid-1960's averaged approximately one-tenth of the military funding. It began to increase slightly in the late Sixties and reached a peak of about 38 million dollars in the mid-Seventies, as a result of 2 programs; the Rotor Systems Research Aircraft (RSRA) and the Tilt Rotor Research Aircraft (TRRA). In the late 1970's, the NASA Advanced Rotorcraft Technology Task Force Report recommended the augmentation of the civil rotorcraft funding as shown in Figure 1.9(a). To date, only a fraction of this program has been approved. As Figures 1.9(b) and 1.9(d) indicate, both civil and military rotorcraft funding are losing ground compared with the National budget growth. (See also amended figures that are attached.)

Information on European funding is too sparse to project. However, the information available over the relatively short five-year period (1970/1975) indicates that it is relatively level and of a magnitude of approximately one-tenth that of the combined U.S. civil and military funding.

Government support of the helicopter industry has always been a major factor in its growth, both in Europe and the United States, taking the form of subsidies and military development and production contracts.

Unlike the European industry where products are tailored to meet multinational requirements, the U.S. industry tailors products to more specific requirements. For example, the UH-1 was tailored to an infantry squad, the AH-1 was tailored to the armed attack role, and the CH-47 was tailored to the battlefield support role. Until recently, U.S. commercial helicopters larger than the three-passenger size have been close derivatives of military helicopters. The recently introduced Sikorsky S-76 was an exception, being tailored to the offshore petroleum support role. The Bell 222 is another exception, being tailored to the corporate market. Both the S-76 and the Bell 222 are company developed and are produced without subsidy or a base military production contract. They are the only helicopters (other than 1-3 passenger) in worldwide production without government support.

There are only three helicopter programs in the free world based upon consortium agreements (as opposed to License Agreements). The Aerospatiale/Westland consortium initial production of the SA 341 Gazelle, SA 330 Puma and WG-13 Lynx for the U.K. and France has been virtually completed. All three models have enjoyed good third country sales. The only other consortiums (as opposed to one-way license agreements) are the MBB/Kawasaki BK 117 and the Westland/Agusta EH-101. Neither of these are far enough advanced to assess their impact on rotorcraft growth/products.

Inherent in the consortium approach is compromise as to performance criteria, and inertia of governments in solving problems of division of work, financing, and government paper work. For these reasons, to date no multinational (as opposed to binational) consortium for rotorcraft design and production has gotten off of the ground.

TABLE 1.9(a). - RESEARCH & DEVELOPMENT FUNDS INVESTED FOR CIVIL ROTORCRAFT ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
UNITED STATES	.40000	.50000	.60000	.90000	1	1.8	1.6	1.6	2.4	4	5.5
FRANCE											13.5
UK/FRG/ITALY											
JAPAN											
TOTAL RESEARCH	.40000	.50000	.60000	.90000	1	1.8	1.6	1.6	2.4	4	19

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
UNITED STATES	5.5	6	5.2	12	21	32.8	18.2	11	14.8	18.6	40.7
FRANCE	13.5	10.9	8.2	9.1	10.2	12.1					
UK/FRG/ITALY		4	6.6	9.3	7.3	5.5					
JAPAN											
TOTAL RESEARCH	19	20.9	20	30.4	38.5	50.4	18.2	11	14.8	18.6	40.7

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
UNITED STATES	40.7	52.4	66.1	70.3	68	69.7	59.8	53.2	44.2	33.6	25
FRANCE											
UK/FRG/ITALY											
JAPAN											
TOTAL RESEARCH	40.7	52.4	66.1	70.3	68	69.7	59.8	53.2	44.2	33.6	25

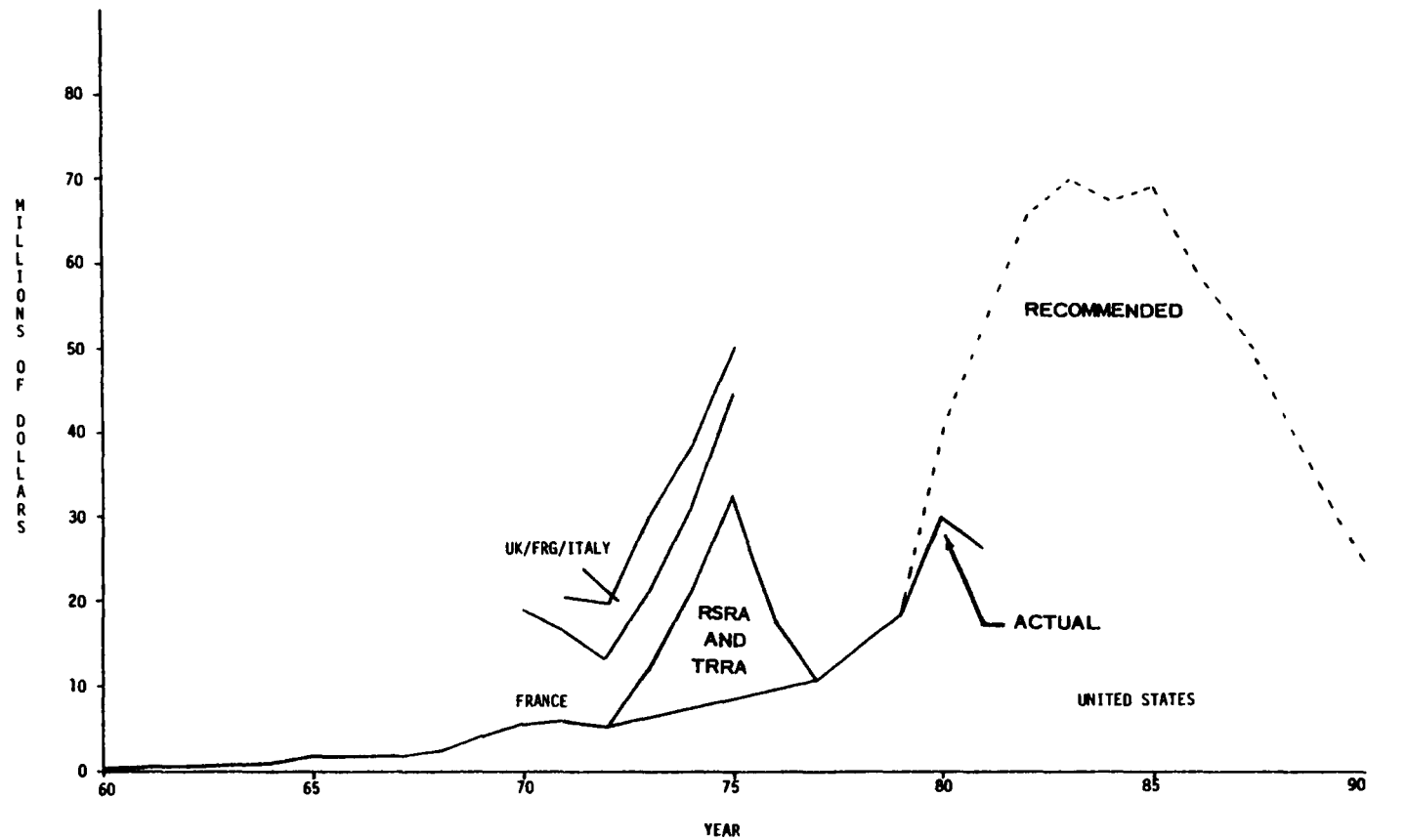

Figure 1.9(a). - Research & development funds invested for civil rotorcraft ($ millions).

TABLE 1.9(b). - PERCENT OF NATIONAL BUDGET INVESTED FOR CIVIL ROTORCRAFT

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
UNITED STATES	.0005	.0006	.0007	.0010	.0010	.0019	.0015	.0013	.0014	.0022	.0028
FRANCE											.0459
UK/FRG/ITALY											
JAPAN											
TOTAL PERCENT	.0005	.0006	.0007	.0010	.0010	.0019	.0015	.0013	.0014	.0022	.0487

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
UNITED STATES	.0028	.0028	.0022	.0048	.0078	.0100	.0050	.0027	.0033	.0037	.0077
FRANCE	.0459	.0343	.0213	.0176	.0200	.0196					
UK/FRG/ITALY		.0046	.0064	.0069	.0052	.0031					
JAPAN											
TOTAL PERCENT	.0487	.0417	.0299	.0293	.0330	.0327	.0050	.0027	.0033	.0037	.0077

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
UNITED STATES	.0077	.0085	.0092	.0088	.0076	.0070	.0053	.0042	.0031	.0021	.0014
FRANCE											
UK/FRG/ITALY											
JAPAN											
TOTAL PERCENT	.0077	.0085	.0092	.0088	.0076	.0070	.0053	.0042	.0031	.0021	.0014

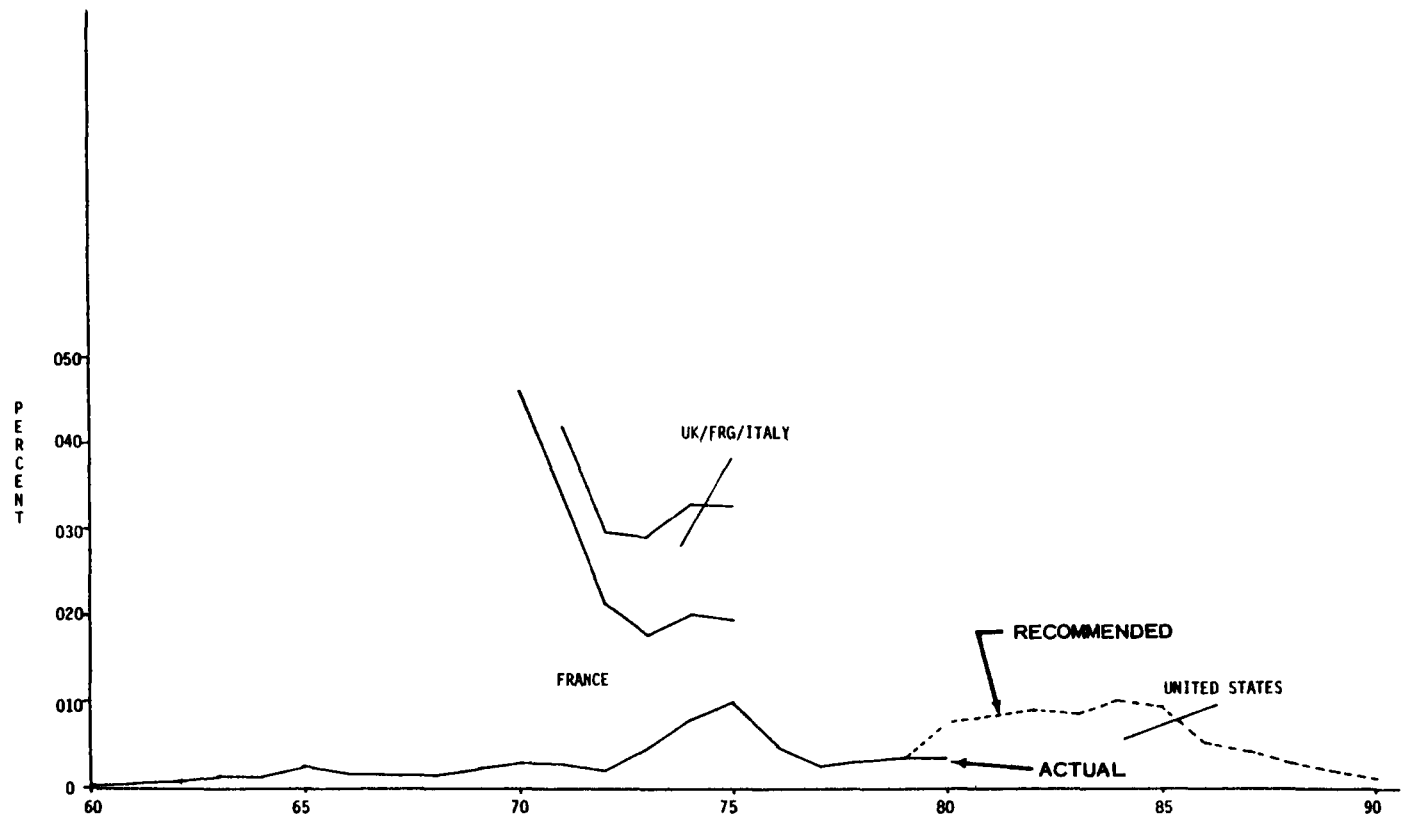

Figure 1.9(b). - Percent of national budget invested for civil rotorcraft.

TABLE 1.9(c). - RESEARCH & DEVELOPMENT FUNDS INVESTED FOR MILITARY ROTORCRAFT ($ MILLIONS)

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
UNITED STATES		.52100	29	11	6.1	5.8	61.1	64.3	68.4	92.1	66.1
FRANCE											13.5
UK/FRG/ITALY											
JAPAN											
TOTAL RESEARCH		.52100	29	11	6.1	5.8	61.1	64.3	68.4	92.1	79.6

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
UNITED STATES	66.1	88.1	161	206.5	324.7	321	308.7	417	482.5	464.7	553.1
FRANCE	13.5	10.9	18.2	9.1	10.2	12.1					
UK/FRG/ITALY		4	6.6	9.3	7.3	5.5					
JAPAN											
TOTAL RESEARCH	79.6	103	185.8	224.9	342.2	338.6	308.7	417	482.5	464.7	553.1

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
UNITED STATES	553.1	469.7	427.4	412.1	435.9	490.2	502.2	512	520	530	534
FRANCE											
UK/FRG/ITALY											
JAPAN											
TOTAL RESEARCH	553.1	469.7	427.4	412.1	435.9	490.2	502.2	512	520	530	534

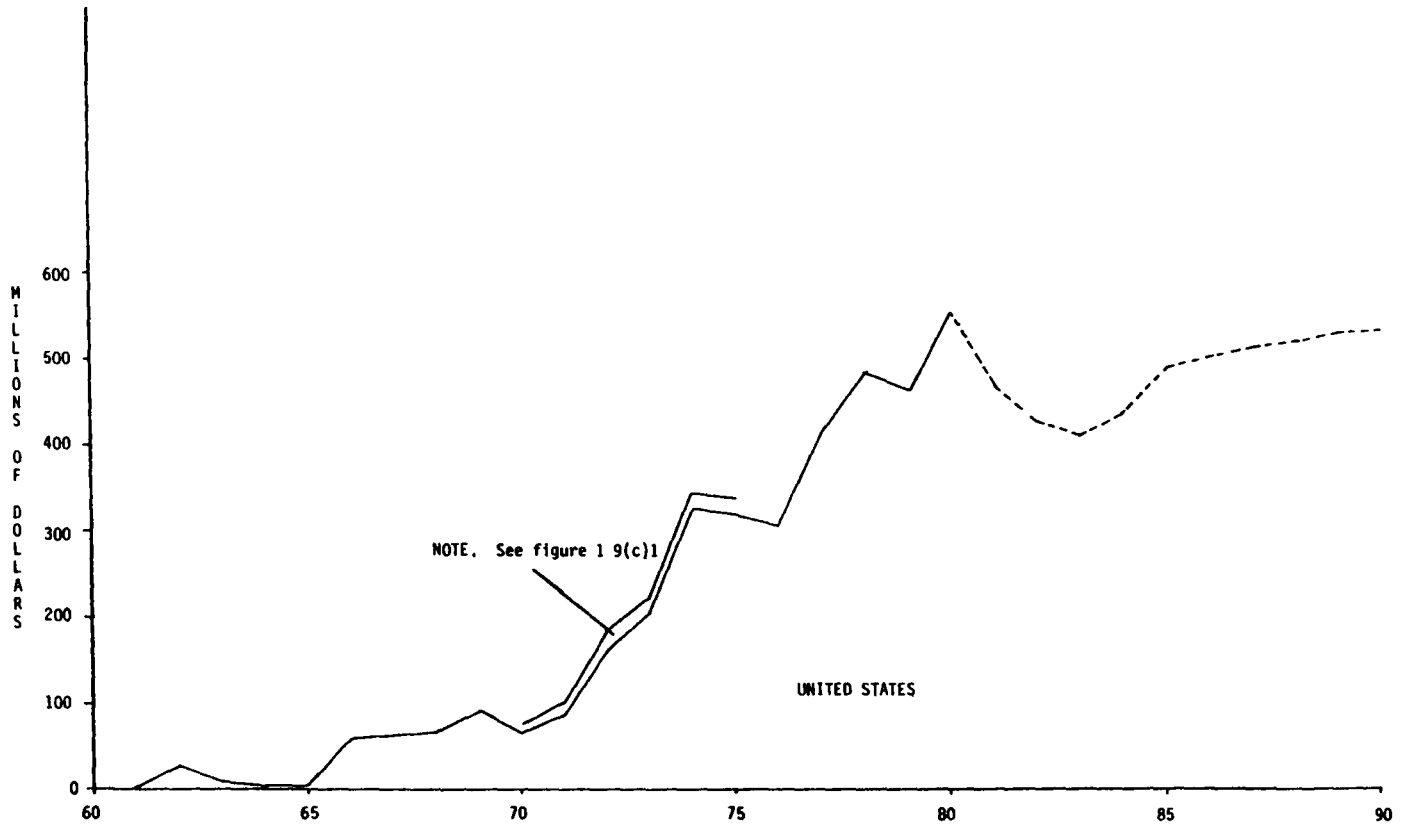

Figure 1.9(c). - Research & development funds invested for military rotorcraft ($ millions).

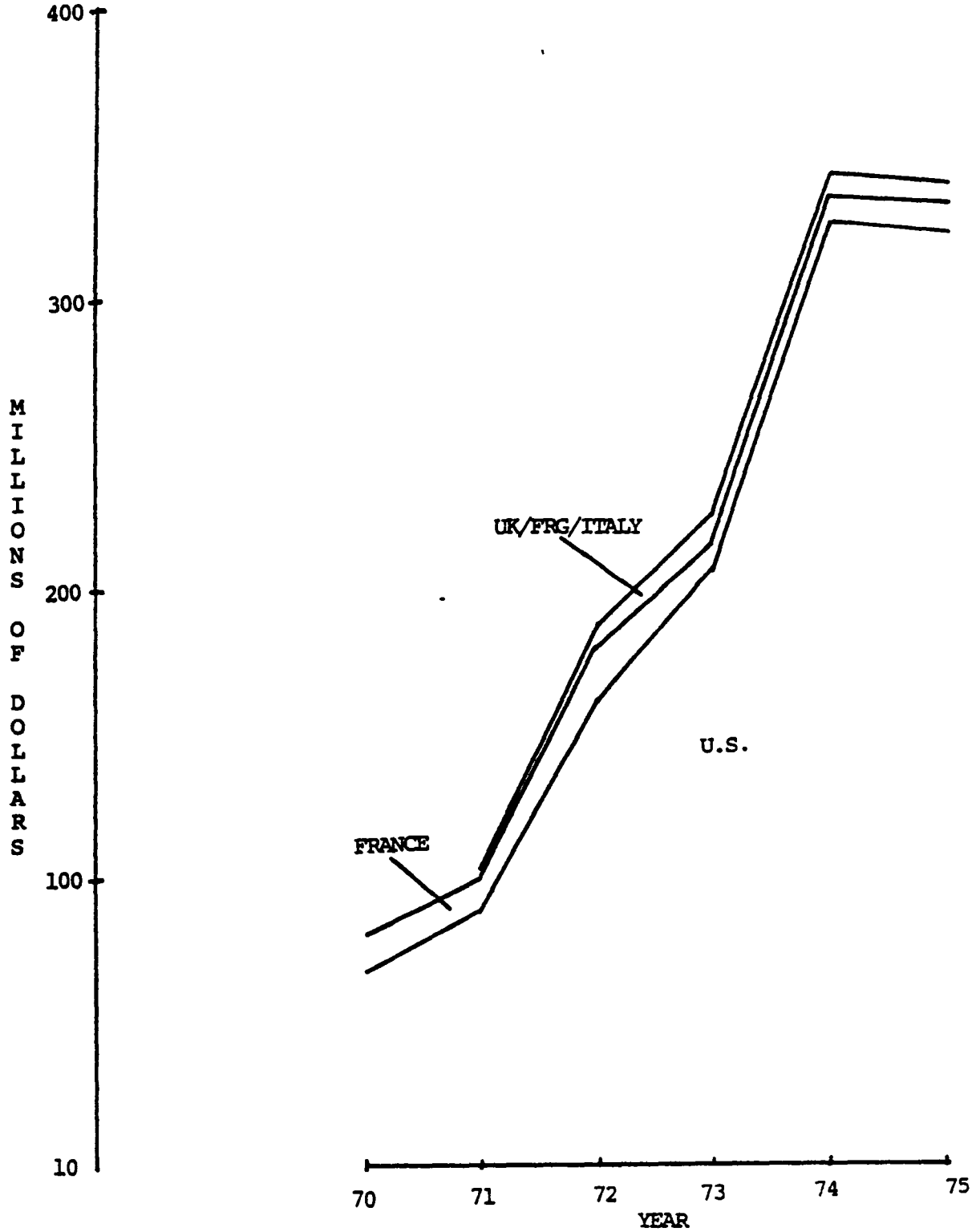

Figure 1.9(c 1). - Research & development funds invested for military rotorcraft ($ millions).

TABLE 1.9(d). - PERCENT OF NATIONAL BUDGET INVESTED FOR MILITARY ROTORCRAFT

	HISTORY										
	60	61	62	63	64	65	66	67	68	69	70
UNITED STATES			.03260	.01190	.00620	.00600	.05760	.05110	.03960	.04990	.03360
FRANCE											.04590
UK/FRG/ITALY											
JAPAN											
TOTAL PERCENT			03260	.01190	.00620	.00600	.05760	.05110	.03960	04990	.07950

	HISTORY										
	70	71	72	73	74	75	76	77	78	79	80
UNITED STATES	.03360	.04160	06940	.08260	.12040	.09840	.08440	.10350	.10700	.09290	.10400
FRANCE	.04590	.03430	.02130	.01760	.02000	.01960					
UK/FRG/ITALY		.00460	.00640	.00680	.00520	.00310					
JAPAN											
TOTAL PERCENT	.07950	.08050	.09710	.10700	.14560	.12110	.08440	.10350	.10700	.09290	.10400

	FORECAST										
	80	81	82	83	84	85	86	87	88	89	90
UNITED STATES	.10400	.07630	.05940	.05150	.04840	.04900	.04440	.04060	.03690	.03370	.03020
FRANCE											
UK/FRG/ITALY											
JAPAN											
TOTAL PERCENT	.10400	.07630	.05940	.05150	.04840	.04900	.04440	.04060	.03690	.03370	.03020

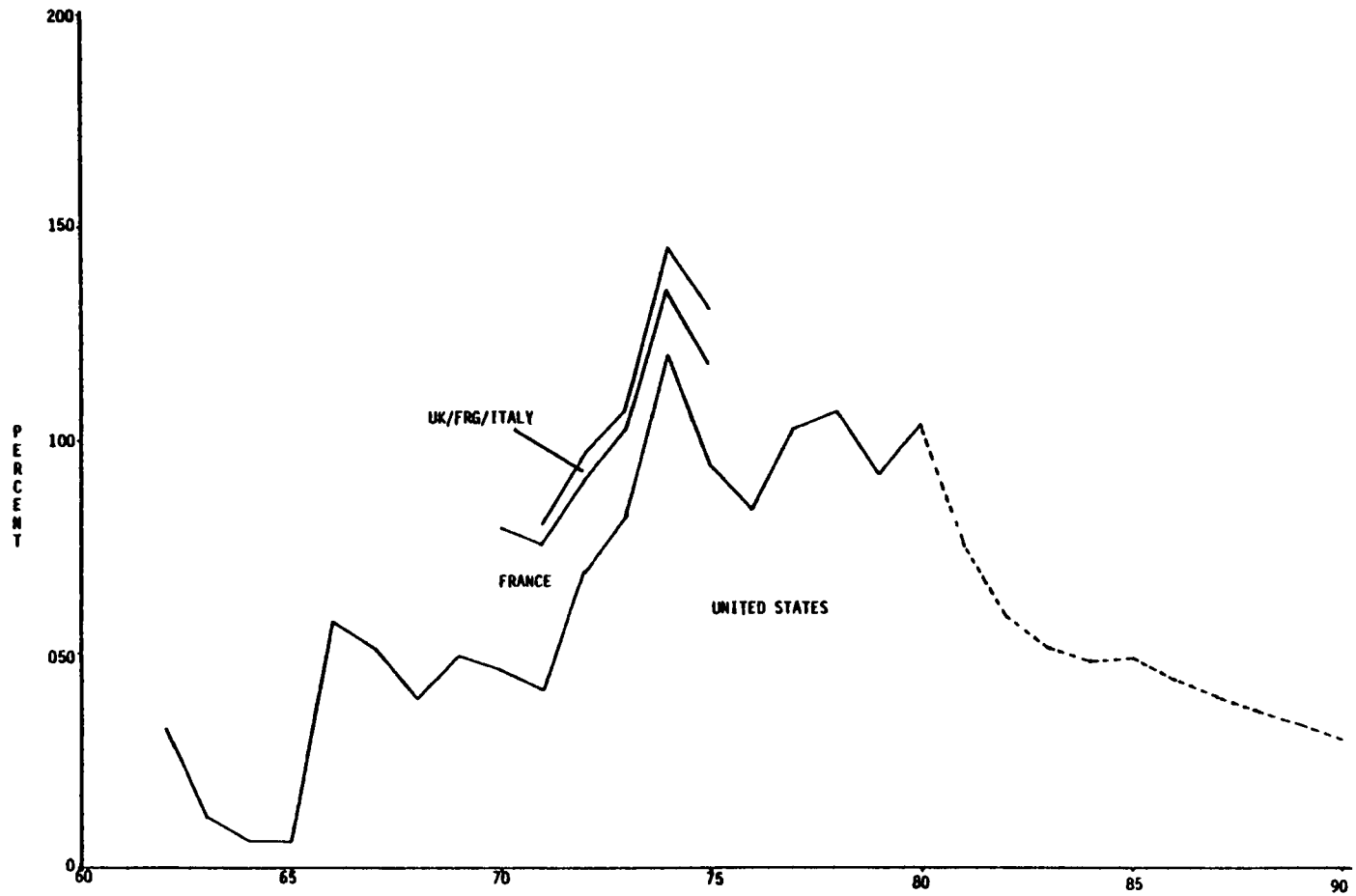

Figure 1.9(d). - Percent of national budget invested for military rotorcraft.

Task 1.10 - Key influences on helicopter growth/markets such as noise regulation, government support, pilot shortages, etc.

Key Influences on Helicopter Growth - Rotorcraft have high direct operating costs; therefore, they are efficient in transportation scenarios where the total transportation cost is important or where other means are inadequate or nonexistent. These scenarios include mountainous terrain, jungles and forests, swamps, river crossings, turbulent seas, and congested population centers. They are used in these areas of construction where other means are too costly in time or money. Their use is driven by political, economic, and social demands. The overriding factor driving political and economic demands is the need for energy, or a resource to trade for energy, and the need to protect it. The overriding factor satisfying social demands is the wealth derived from energy or a resource that may be traded for energy. (See Enclosure I). Within these broad parameters, there are many lesser, more specific influences that will also affect helicopter markets.

The Noise Control Act of 1972 established the Congressional mandate "to promote an environment for all Americans free from noise that jeopardizes their health and welfare." To that end, the FAA was assigned the responsibility for the control of aircraft noise after consultation with the Secretary of Transportation and with the EPA. The FAA Helicopter Noise Policy, as proposed, will have a profound effect on the helicopter market and its growth. As written, this policy will seriously jeopardize aircraft currently being developed for certification, significantly adding to the already high development costs. Additional penalties can be expected in terms of payload, speed, and fuel consumption. Since some 60 percent of U.S. population is destined for overseas markets, foreign competitors will have an insurmountable advantage. Further, for all intents and purposes, the U.S. market will be closed to foreign manufacturers.

The heart of this problem lies in the fact that although helicopter noise levels are lower than fixed wing, the helicopter industry is asked to respond more quickly. The fixed wing industry was better prepared at the time the regulation was issued in that turbo fan technology had been demonstrated, major NASA noise contracts were underway, and the business base was 17 times greater. The FAA Noise Policy recommendations call for implementation, with exemptions and tolerances, based on fixed wing precedence. The helicopter industry maintains that there is need for an Economical Reasonableness and Technological Practicability (ERTP) study, which must be based on complete and valid measurement of all helicopters affected, and economic analysis that uses results from a complete data base.

In the final analysis, community acceptance will probably be the ultimate judge of acceptable helicopter noise levels. Experience has shown that when helicopter operations are initiated in a community, people tend to object not to the noise level, but to the noise signature peculiar to the helicopter. Acceptance, however, comes about relatively quickly. A case in point is Aberdeen, Scotland, where citizens initially complained about the "flop-flop" sounds of the two-bladed rotors when operations started. Today, noise complaints are minimal, and helicopter traffic is an accepted routine of life.

In order to realistically consider the types of advanced helicopters envisioned in Task 2, extraordinary development expenditures will be required. Historically, the military established design and performance criteria, fully recognizing that nonrecurring development costs (NRDC) would be paid for as part of the contract price. In today's climate, the civil user is establishing criteria, but so far is apparently unwilling or unable to absorb the NRDC in the helicopter price. In looking to the future, NRDC can be expected to escalate as new criteria are established, and manufacturers will be hard pressed to expend such funds and remain in a profitable posture. Government assistance is urgently needed in this area, in the form of tax incentives for new technology development and in accelerated sponsored research and development programs. Lack of such assistance, or the absence of major military procurements involving new design, will serve as a retardant to the application of advanced technology.

Private training for the prospective helicopter pilot is quite expensive. After incurring this high expense, the new helicopter pilot finds that he is unable to profitably use his new skills because insurance rates for pilots with less than 1000 hours of rotary wing time are so prohibitively high as to render him unemployable.

The demand for pilots and mechanics will increase dramatically by 1990 as indicated by the forecast contained in this report. As demand for trained personnel increases and the supply decreases, solutions to this dilemma must be found. Government assistance may be required, not only in the U.S., but throughout the free world. Requiring mechanic licenses to reflect helicopter versus fixed wing qualification might well serve to improve mechanic quality, provide incentives for schools to provide appropriate training, and add a measure of prestige to the status of the mechanic. Obstacles to employment of the new pilot will have to be removed, providing incentive for people to obtain helicopter flight training. Insurance companies will have to be convinced of the safety of

the new pilot. This will probably involve improved training techniques, simpler helicopter operation, and improved helicopter reliability.

The most unique feature of a helicopter is the lack of need for a long runway. This leads to an obvious market of downtown-to-downtown or downtown-to-airport passenger movement, yet this is virtually untapped with the possible exception of the government subsidized efforts of British Airways. Some of the reasons for this include lack of downtown heliports, lack of public acceptance, and high direct operating costs.

Public heliport planning and funding badly lags behind projected helicopter fleet increases. Government action is required immediately in the U.S. at both the national and local level, and to a relative degree, throughout the population centers of the free world.

The wide publicity frequently given to a serious helicopter accident has served to shake public confidence in the helicopter as a means of passenger transportation. As reliability improves, a corresponding decrease in accident rates occurs. A good deal of favorable publicity will be needed to gain the confidence of the general public.

Several entrepreneurs have attempted scheduled helicopter operations in the U.S., but have failed for a variety of reasons, not the least of which was marginal profitability. Significant improvement in fuel consumption, insurance rates, and maintenance costs will be required if profitability is to be assured.

U.S. helicopter manufacturers face formidable competition from foreign manufacturers who receive financial aid from their governments. This aid may be in the form of subsidies, low cost loans to the manufacturer, or low interest financing to the customer. Generally, U.S. manufacturers have been able to compete successfully by offering superior post-sale support, but foreign manufacturers are taking actions to improve their customer support services, and might enjoy a competitive parity in the near future. In recent years, the advantages held by foreign competition have been offset to some degree by the devalued dollar on the international exchange. This condition is due to be reversed. If the U.S. is to maintain world leadership in the helicopter industry, solutions to the high cost of financing will be required.

A review of reactions from abroad concerning the results of the recent U.S. elections reveals that there is a great deal of hope that the U.S. government will provide more assistance in supporting the sale of U.S. products internationally. This

hoped-for support is not only in the form of direct offsets and better financing, but also through active support by foreign service personnel in promoting U.S. products abroad with the goal of resuming the role of world leadership.

The rising cost of fuel does not appear to have a direct correlation with aviation sales, except as it affects the general economy in a recessionary period. The need for more fuel-efficient engines has emerged, as has an increased market for helicopters in energy discovery and production, particularly in the offshore oil business. In a larger sense, however, it is generally accepted that, on a world wide basis, the consumption of petroleum exceeds the rate of discovery of additional resources. At some point in time, these two lines will cross, creating a petroleum shortage that will have a dramatic impact on the aviation industry. It may be expected that as individual countries begin to recognize an inability to obtain oil, there will be increased activity in oil exploration, possibly resulting in an increase of helicopter activity at that time. Eventually, however, different fuels will have to be developed, or a different type of power plant invented for aircraft. The most promising prospect is probably in the area of synthetic fuels, but this development program will require time, money, and high priority if it is to be realized in the near term.

The U.S. is the world leader in the certification process for new aircraft. This has and continues to promote consumer confidence in the product, and serves to enhance safety and reliability. It is, however, an increasingly expensive process, and these costs must be amortized in the sales price of the aircraft. Foreign helicopter manufacturers generally face less stringent certification requirements, thus serving to reduce development costs. This current competitive advantage may eventually disappear as consumers throughout the world demand the assurances provided by strict certification standards.

Task 1.11 - A review of the relative strengths and weaknesses of U.S. helicopter technology relative to non-U.S. technology.

Strengths and Weaknesses of U.S. Helicopter Technology - Much of the discussion herein is based upon selected sections of the "Vertical Lift Technology Review Final Report" prepared for the Assistant Secretary of the Army for Research, Development, and Acquisition. The report was prepared 26 June 1980 with active participation of both government and industry. Bell Helicopter Textron made substantial contributions to this report.

This review addresses aeromechanics, propulsion, airframe and rotor structures, reliability/availability/maintainability, crashworthiness, electronics, and configuration.

A thorough understanding of aeromechanics is the keystone to rotorcraft technology. The dynamic interaction of rotor flow with airframe structure through a wide spectrum of velocity and angles of attack is very complex and ill defined. The U.S. industry technology base in rotorcraft aeromechanics is much broader and deeper than that of foreign industry. However, foreign industry, heavily supported, financed (and in some instances owned) by their governments, has the ability to assimilate technology and more quickly convert it into hardware. The United States can maintain its lead in aeromechanics provided joint industry/government efforts are created to focus on methods for predicting fuselage vibration and oscillatory structural loads and the interaction of fuselage and main and tail rotors with the ground at low altitudes and flight speeds. Continued attention must be paid to advanced flight control work to include fiber optics. The French are pursuing the U.S. closely in the area of reduced rotor dynamic loads and aircraft vibration. If these avenues to improved understanding of aeromechanics are pursued, a 25 percent improvement in hovering payload should be achievable and is necessary to stay in advance of foreign industry.

Progress in engine development offers one of the larger potentials for improvement in propulsion -- not only in fuel consumption, payload, reliability and maintainability -- but particularly in performance. Development should continue in the 300/400 HP range, the 800 HP range, the 4,000/5,000 HP range and the 8,000 HP range. Not only should higher pressure ratios and shaft speeds be pursued, but emphasis should be given to fuel economy through such devices as regeneration, variable geometry for partial power operation, and alternate fuels. U.S. engine technology is considered to be generally superior to that of foreign industry; however, the French Turbomeca Arriel and Makila engines and the English Rolls Royce Gem IV are considered to be very competitive. The Russians also emphasize engine growth rather than airframe sophistication.

With the possible exception of very heavy lift helicopters, the mechanical gear-driven transmission will remain unchallenged as the best means of transferring power from the engine to the rotor. U.S. technology is clearly well ahead of foreign competition, particularly in gear grinding for reduced friction. The U.S. also leads in lighter weight per stage per horsepower and special features such as fly-dry. With higher engine-shaft speeds, research must be continued with additional emphasis on reliability and diagnostic systems. Weight reductions of 15 to 20 percent appear achievable over the next 5 to 10 years.

Advanced composites and related manufacturing processes offer the best opportunity to improve technology of airframes and rotors. They can yield weight savings, improved airfoils, and elimination of catastrophic failure inherent in monolithic metallic primary structures. Application of composites to secondary structures is rapidly advancing with Europe and the U.S. technology roughly equal and the Soviet Union lagging. Application of composites to primary airframe structure is developing slowly because of the unavailability of failure criteria for areas with complex loading, uncertain production costs, undeveloped inspection techniques and lack of experienced design personnel. Europe is leading in application of composites to rotor head design and initially took the lead in composite rotor blade design. The U.S. has now forged ahead in rotor blade technology through mechanized manufacturing methods involving fiber spinning with variable geometry.

The U.S. clearly leads in the technology of aircraft reliability and maintainability across the broad spectrum of helicopters. However, the French are making a major thrust with their latest models. Emphasis should be placed on application of microelectronics to diagnostics and system monitoring.

U.S. industry and government clearly lead the world in crashworthiness technology, and the U.S. military standards are the basis for worldwide standards.

Considerable advances have been made in microelectronics and digital techniques, which have made avionic equipment lighter, more flexible and more reliable -- particularly in the area of digital integration and multiplexing. The U.S. has a clear lead in this technology and through concerted research efforts additional major advancements can be expected in the near future.

Advances in sensor technology are leading to improved night and all-weather operations, taking the form of Forward Looking Infrared (FLIR), millimeter wave radar, and carbon dioxide laser developments. Hybrid multispectral sensor presentations

show great promise for improved cockpit display of terrain, flight obstructions, and other aircraft for both enroute operations and operations in terminal areas. The U.S. appears to be leading in sensor technology.

Studies show that a concentrated coordinated effort on all rotorcraft technology fronts could, over the next decade, provide a combining effect of reducing weights by up to 30 percent and fuel required by up to 40 percent, a step forward comparable to introduction of the gas turbine.

Departing from the concept of a pure rotorcraft, there are several areas that should be pursued. For missions requiring hover efficiency and dash speeds up to 200/250 knots, the advancing blade concept is most attractive. For high-speed, long-range cruise (250/400 knots), the tilt rotor offers an excellent solution, because of its inherent excellent high-speed lift-to-drag ratio. The tilt rotor also provides an alternative with good low-speed characteristics. The U.S. has a clear lead in these technologies.

Task 1.12 - Other tasks deemed of value in obtaining a good understanding of rotorcraft markets. This study is considered to be quite comprehensive; therefore, no additional tasks are offered at this time.

TASK 2

A civil market forecast study to indicate sensitivity to new technology for the period 1960 through the year 2000 -- Forecast rationale to include the following premises:

- A model life of a vehicle shall be 15 years or less.
- There will be continued emphasis on aircraft noise standards.
- Fuel consumption costs, increased rates will be projected.
- The GNP will expand at a moderate-to-good rate annually of 4 percent in constant dollars.
- Air traffic in terms of passengers will grow at 6 percent per year but no new major conventional airport facilities will be constructed.

Worldwide civil helicopter forecasts will be made, based on the following technology capability scenarios:

- Establish a forecast baseline case assuming present technology as represented by the B-222, S-76, BV 234, H-500, etc.
- By 1985, there will be a 15 percent improvement in speed, range, payload, quietness, reduced vibration, and DOC over the best of the present technology.
- By 1990, there will be an operational 225-passenger rotorcraft having a cruise speed of 180 knots, a range of 600 NM and a $0.04 DOC/Seat/Mile.
- By 1990, there will be an operational heavy-lift rotorcraft having an external lift capability of 35 tons, an external lift cruise speed of 100 knots, an internal cruise payload of 30 tons, an internal load cruise speed of 180 knots, an internal load cruise range of 600 NM and a DOC of $0.40/ton miles, cruise or lifting.
- By 1990, there will be an operational 50-passenger rotorcraft having a cruise speed of 300 knots, a range of 80 NM, and a DOC of $.04/seat/mile.
- By 1995, there will be an operational 150-passenger rotorcraft having a cruise speed of 350 knots, a range of 800 NM, and a DOC of $.04/seat/mile.

The price of fuel is one of the driving forces that will determine the future of civil aviation. The world price of crude oil increased fivefold between 1973 and 1975 and again doubled in 1979 for a tenfold increase during the decade. The Wharton Economic Forecasting Associates project an increase of 225 percent between 1980 and 1992, an annual increase of slightly more than 10 percent. In view of the history of the 1970's, the fact that there is a pending shortfall of world supply aggravated by the disruption and destruction in Iran and Iraq, and the penchant of OPEC to charge whatever the traffic will bear, the Wharton forecast appears to be ultra conservative. This study uses an average annual price increase of petroleum of 15 percent and an inflation factor of 8 percent.

The impact of the fuel price increases is certain to cause the aircraft operators to seek more fuel efficient aircraft. The most likely trend will be a return to turboprop aircraft as soon as new designs can be put into service.

Because of reduced speed the turboprop will be used mostly in medium and shorter stages including inter-city flights of less than 800 nautical miles, for airline and commuter flights.

A recent projection by McDonnell Douglas Corp. foresees a world wide requirement for 6100 new passenger aircraft by 1995 at an investment of $186 billion in constant 1980 dollars. Sixty-three percent of this investment ($117 billion) is expected to be for short and medium range aircraft. The short range portion of this expenditure will be the target of the next generation of rotorcraft reflected in the above scenarious.

The market potential for rotorcraft in this role is high; however, there are major impediments to the development of rotorcraft as a major means of transportation. First and foremost is public acceptance. After several major attempts (in New York, Los Angeles, Chicago, San Francisco), and many minor attempts, the only successful scheduled rotorcraft operations are between the two major airports in London (Heathrow & Gatwick), the operation to the Scilly Islands in the United Kingdom, both of which are heavily subsidized by the government, and the recent restart of operations in and around New York.

By far, the largest potential of high volume, heliport/airport or heliport/heliport operations is city-center-to-airport or city-center-to-nearby-city-center. There are approximately 100 cities worldwide with populations of over one-half million which have good potential for this type of operation, 30 being in the United States. Each city center would serve as a hub of operations to local airports and/or nearby cities.

Primary impediments to development of downtown commercial heliports are public apprehension of noise and accidents. The noise problem will have to be alleviated by advances in technology. Accident apprehension will have to be solved by route patterns away from congested living areas, such as along waterways, automobile freeways, and parkways.

Another major impediment is today's very high cost of bringing a new rotorcraft design to production, normally an eight year cycle. The design, development, long lead time procurement tooling, and certification, require an investment measurable in hundreds of millions of dollars at very high interest rates. These costs must be amortized over the first several years of production unless partially funded by a military procurement.

A third impediment inherent to the route structure of rotorcraft operating from city centers is the competition offered by mass transportation (trains/subways/busses). It is to be noted that 80 percent of air travel in the eastern portion of the U.S. and 60 percent in the western portion is business travel where the time saved in air transportation is measurable in money, as opposed to recreational travel where it is a convenience.

The high cost (initial and operating) of conventional rotorcraft relative to fixed wing, generally limits their application to activities with one of the two flight terminals as heliports, rather than conventional airports. Therefore, the most practical application is city-center-to-airport, and city-center-to-nearby-city-center. The high dash speed of the advancing blade rotorcraft will find this an attractive potential market.

The longer stage city-center-to-city-center, and feeder airline market will be a highly attractive market for the tilt rotor convertiplane. The tilt rotor aircraft will be directly competitive with the turbo prop in performance, and have the added flexibility of being able to operate to and from heliports. Where heliports are required (downtown-to-downtown or offshore) the tilt rotor concept offers an order of magnitude of twice the speed, twice the range, and one-half of the fuel consumption of a conventional rotorcraft.

Task 1.11 discusses in detail technical improvements that can be expected to be made. It points out that a coordinated joint government and industry concentrated effort can yield a 30 percent reduction in rotorcraft airframe weights and a 40 percent reduction in fuel required. Dramatic improvements of this magnitude will put rotorcraft squarely in commuter, city-center-to-city-center, and city-center-to-airport transportation market.

If the advancing blade rotorcraft and the tilt rotor convertiplane aircraft are combined with a coordinated concentrated joint government and industry technical improvement effort, they will make a deep penetration of the short and medium stage air carrier aircraft market and to some extent penetrate the bus and train inter-city market. This is particularly significant to the U.S. aircraft industry in that the U.S. enjoys strong leadership in both the advancing blade and tilt rotor technology.

Another expanding market in which U.S. industry has led is transportation from airports to remote areas such as offshore petroleum platforms. Offshore petroleum operations already employ more than 1000 rotorcraft. Manpower working offshore have already reached high density in the United Kingdom, Norway and high density soon will be reached in Mexico. (In the United States Gulf of Mexico area, the totals of manpower working offshore are high but not as locally concentrated as in the North Sea or expected for the Campos area of Mexico's eastern offshore area.) A 44-passenger helicopter, the Boeing/Vertol Model 234, has been procured by British Airways Helicopters to initiate transportation to some of these high concentration areas (Shell Brent System - 3000 men).

Aerospatiale, of France, combining advanced technology and government sponsorship, is now penetrating this offshore market substantially.

The following discussions, tables and figures address the six technology improvements outlined in Task 2. To make twenty-year projections in units and dollars, certain assumptions were necessary. These are:

a. 1981 empty weight pricing of rotorcraft is approximately $400 per pound. This value, at 1981 pricing, will hold through the year 2000.

b. The 8 percent per annum inflation used for the projections of Task 1 will continue through the year 2000.

c. The mix of sizes of helicopters will be constant between the years 1990 and 2000 for baseline plus 15 percent improvement in technology helicopters.

d. Technology advances will yield 50 percent useful load (crew/fuel/passengers/etc) and design will continue to require approximately 1000 pounds of gross weight per passenger for ranges between 300 and 600 nautical miles. Therefore, the following empty weights for new Task 2 rotorcraft have been estimated:

Large Transport	(225 passenger)	112,500 pounds
Heavy Lift	(30 tons)	30,000 pounds
High Speed Medium	(50 passenger)	25,000 pounds
High Speed Large	(150 passenger)	75,000 pounds

Table 10(a/b) and Figures 10(a) and 10(b) provide an overview of the sensitivity of the free world civil rotorcraft market to new technology in units. Table 10(e) and Figure 10(e) provide the same information converted to dollars.

Forecast of the Commercial Rotorcraft Delivery Base Line Assuming Present Technology

The present growth of helicopters and their penetration of the transportation market, both surface and air, is a direct result of their improved safety and efficiency made possible by rapidly advancing technology described in Task 1.11. Task 1.7 points out that attrition in commercial fleets is very low.

Without constant improvement in technology of rotorcraft, as can be expected in other modes of transportation, a base line of market penetration can be expected to stagnate by the early 1990's and in fact enter a decline as the year 2000 approaches.

The recent advances in technology made by the European rotorcraft industry are reflected in the substantial decrease in the U.S. share of the free world market beginning in 1980.

Table 10(c) and Figure 10(c) project the U.S. base line and the free world base line in units assuming no improvement in existing technology. Technological improvements in surface transportation and fixed wing aircraft soon check the inroads rotorcraft have been making in transportation and reverse the trend. Table 10(f) and Figure 10(f) show similar information in dollars.

Sales of a heavy lift (35-ton) rotorcraft will exceed medium lift sales in gross dollars but will take a long period of hard selling and demonstrations to prove the cost effectiveness requires very large R&D effort to develop technology of the system. Sales are expected to build to 24 units per year over a 5-year period.

Forecast of the Sale of a High Speed Medium Rotorcraft by 1990

This rotorcraft is pointed at the commuter airline market, serving the small outlying areas from major population centers.

With airline deregulation, many of the communities, previously served by short to medium haul transport aircraft, are being or will soon be serviced by commuter airlines.

For rotorcraft to compete substantially in this market, they will of necessity be of the advancing blade or tilt rotor configuration discussed in Task 1.11. They also must have city-center facilities and be accepted by the community.

If impediments can be overcome, rotorcraft should be able to seize 25 percent of this market from the fixed wing aircraft. A joint venture between Aeritalia and Aerospatiale estimates this market to be between 2500 and 3000 aircraft between 1985 and the year 2000 (see Aviation Week 15 September 1980). This would mean the sale of 50 units per year.

Another market for this helicopter is offshore resources exploration and development. Approximately 40 medium helicopters per year are now sold into this market with very rapid growth expected. The long range high speed tilt rotor should seize a good portion of this market as exploration pushes further and further offshore. Sales are expected to reach a level of 25 units per year by 1995.

Forecast of the Sale of Large, High Speed, Long Range Rotorcraft

This rotorcraft is pointed at the short and medium haul transport market. To compete substantially, it must have the capabilities and cost effectiveness of a tilt rotor.

By the mid-1980's, substantial numbers of the existing fleet of 3500 aircraft will be more than 20 years old and need replacement (see Flight International 30 August 1980). As previously stated, McDonnell Douglas foresees a market for approximately 4000 units by 1995. The high cost of fuel is expected to force a good portion of this market back to turboprops. The tilt rotor should be able to achieve a sales level of 50 units per year by the end of the forecast period.

Tables & Figures 10(d) in units and 10(g) in dollars show the U.S. baseline rotorcraft market share of the total free world rotorcraft market with advanced technology and the development of new line of large, high speed and heavy lift helicopters. It is certain that foreign industry and governments will continue increasing investment in technology and rotorcraft development. If the U.S. does not also vigorously pursue this course, our current (1980) share can be expected to drop from 74% in units and 69% in dollars to 29% in units and 13% in dollars by the year 2000.

Technology Needs

The preceding sections have presented forecasts of markets available to rotorcraft and have identified critical issues regarding the technology upon which these forecasts are based. Foremost is the issue of rotorcraft noise reduction from the standpoint of both meeting regulatory requirements and achieving community acceptance. This single issue can have a devastating impact on the ability of U. S. manufacturers to compete successfully in the expanding civil market. Programs that improve the capability to predict noise with better confidence are an essential element in reducing the risk of a new helicopter development. Coupled with this noise prediction capability is the need for innovative techniques to minimize noise without degrading productivity of the rotorcraft (i.e., payload, speed and range). These needs will intensify as vehicle sizes increase and the development risk escalates as would be the case for the large transport rotorcraft, a heavy-lift rotorcraft, and even the high-speed medium rotorcraft.

Inherent in the current trend of rotorcraft development is the continuing divergence of the design philosophy between military and commercial products. As has been pointed out, there are only two U. S. manufactured commercial rotorcraft with seating capacity greater than three that are not derivatives of military vehicles. Current military specifications that stress ballistic tolerance, survivability, and other military requirements have created a situation where very little of the final product is applicable to a commercially viable product. Consequently, there is a significant need for research and development support directed specifically to the commercial rotorcraft to enhance the U. S. technical position in both the domestic and international market.

This technical position encompasses a wide spectrum of technology needs. Specific areas include accelerated efforts to capitalize on two burgeoning technology fronts - advanced composite materials and the microprocessor. Accelerated application of composites to all areas of the helicopter (rotor hubs, blades, and fuselage) offers significant reductions in empty weight and in cost, while increasing the service life by minimizing corrosion problems. The microprocessor technology provides a revolution in its impact on rotorcraft. Efforts are needed to capitalize on the information storage and processing capabilities of these relatively low cost microcomputers in order to achieve such commercially attractive benefits as improved handling qualities, reduced pilot workload, and single pilot IFR. A major outgrowth of this technology thrust would be a helicopter with all-visibility operational capability. Coupled with this thrust is the need for improved sensors and displays.

For the larger helicopters and also the tilt rotor, the benefits of fly-by-wire or fly-by-light should not be neglected. Reductions in weight and cost and improved reliability and maintainability are benefits strongly supportive of a viable commercial product.

Given some of the synergistic benefits of the preceding technology thrusts, a very competitive series of commercial products can evolve. However, there is the need for research effort on engines and fuels, not only from the standpoint of reduced SFC but to achieve wider tolerance on fuel specifications. The ability to burn alternate fuels in the same engines will become increasingly important over the coming years.

Much of the basic technology has been researched and shown applicable to advancing the productivity of rotorcraft. With the diverging requirements between civil and military helicopters, it is imperative that NASA accept the vital roll of focusing high technology programs on civil helicopter applications.

Advancing the productivity of the United States manufactured helicopter can be achieved only through the incorporation of advanced technology. This is needed to maintain a competitive U. S. position in the world helicopter market.

TABLE 10. - FREE WORLD CIVIL ROTORCRAFT SENSITIVITY TO NEW TECHNOLOGY

	60	61	62	63	64	65	66	67	68	69	70
BASELINE	222	330	370	450	480	421	413	508	569	550	548

	70	71	72	73	74	75	76	77	78	79	80
BASELINE	548	558	625	1040	913	861	803	757	838	1350	1699

	80	81	82	83	84	85	86	87	88	89	90
BASELINE	1699	1851	1952	2020	2101	2180	2262	2211	2344	2413	2441
15% IMPROVEMENT	--	--	--	74	120	189	237	412	397	440	552
TOTAL	1699	1851	1952	2094	2221	2369	2499	2623	2741	2853	2993

	90	91	92	93	94	95	96	97	98	99	2000
BASELINE	2441	2478	2498	2495	2482	2467	2443	2399	2360	2302	2224
15% IMPROVEMENT	546	594	688	775	889	998	1046	1293	1439	1602	1799
LARGE TRANSPORT	2	9	12	18	24	24	24	24	24	24	24
HEAVY LIFT	2	6	9	12	15	18	21	24	24	24	24
HIGH SPEED MEDIUM TRANSPORT	2	12	24	48	60	75	75	75	75	75	75
HIGH SPEED LARGE TRANSPORT	--	--	--	--	--	2	12	24	36	48	50
TOTAL	2993	3099	3231	3348	3470	3582	3621	3839	3958	4075	4196

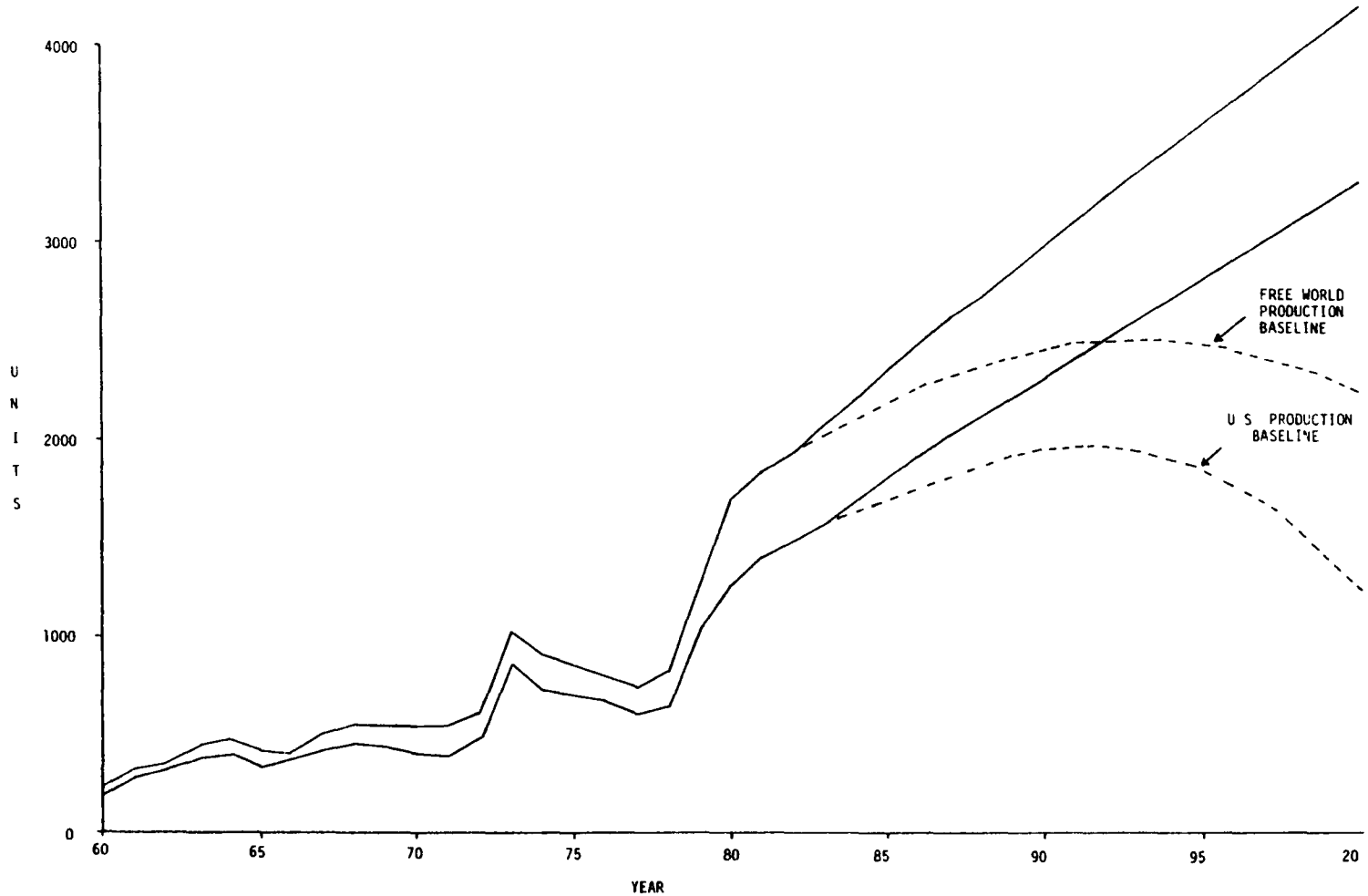

Figure 10. - Free world civil rotorcraft market sensitivity to new technology (units).

TABLE 10(a/b). - FREE WORLD CIVIL ROTORCRAFT MARKET SENSITIVITY TO NEW TECHNOLOGY (UNITS)

	60	61	62	63	64	65	66	67	68	69	70
BASELINE	222	330	370	450	480	421	413	508	569	550	548

	70	71	72	73	74	75	76	77	78	79	80
BASELINE	548	558	625	1040	913	861	803	757	838	1350	1699

	80	81	82	83	84	85	86	87	88	89	90
BASELINE	1699	1857	1952	2030	2105	2180	2245	2305	2355	2402	2442
15% IMPROVEMENT	--	--	--	+64	+116	+189	+241	+325	+370	+461	+553
TOTAL	1699	1857	1952	2094	2221	2369	2486	2630	2725	2863	2995

	90	91	92	93	94	95	96	97	98	99	2000
BASELINE	2442	2480	2490	2500	2495	2470	2415	2402	2360	2302	2212
15% IMPROVEMENT	+553	+617	+709	+801	+908	+1035	+1192	+1307	+1451	+1611	+1803
LARGE TRANSPORT	+2	+9	+12	+18	+24	+24	+24	+24	+24	+24	+24
HEAVY LIFT	+2	+6	+9	+12	+15	+18	+21	+24	+24	+24	+24
HIGH SPEED MEDIUM TRANSPORT	+2	+12	+24	+48	+60	+75	+75	+75	+75	+75	+75
HIGH SPEED LARGE TRANSPORT	--	--	--	--	--	+2	+12	+24	+36	+48	+50
TOTAL	3001	3124	3244	3379	3502	3624	3739	3856	3970	4084	4188

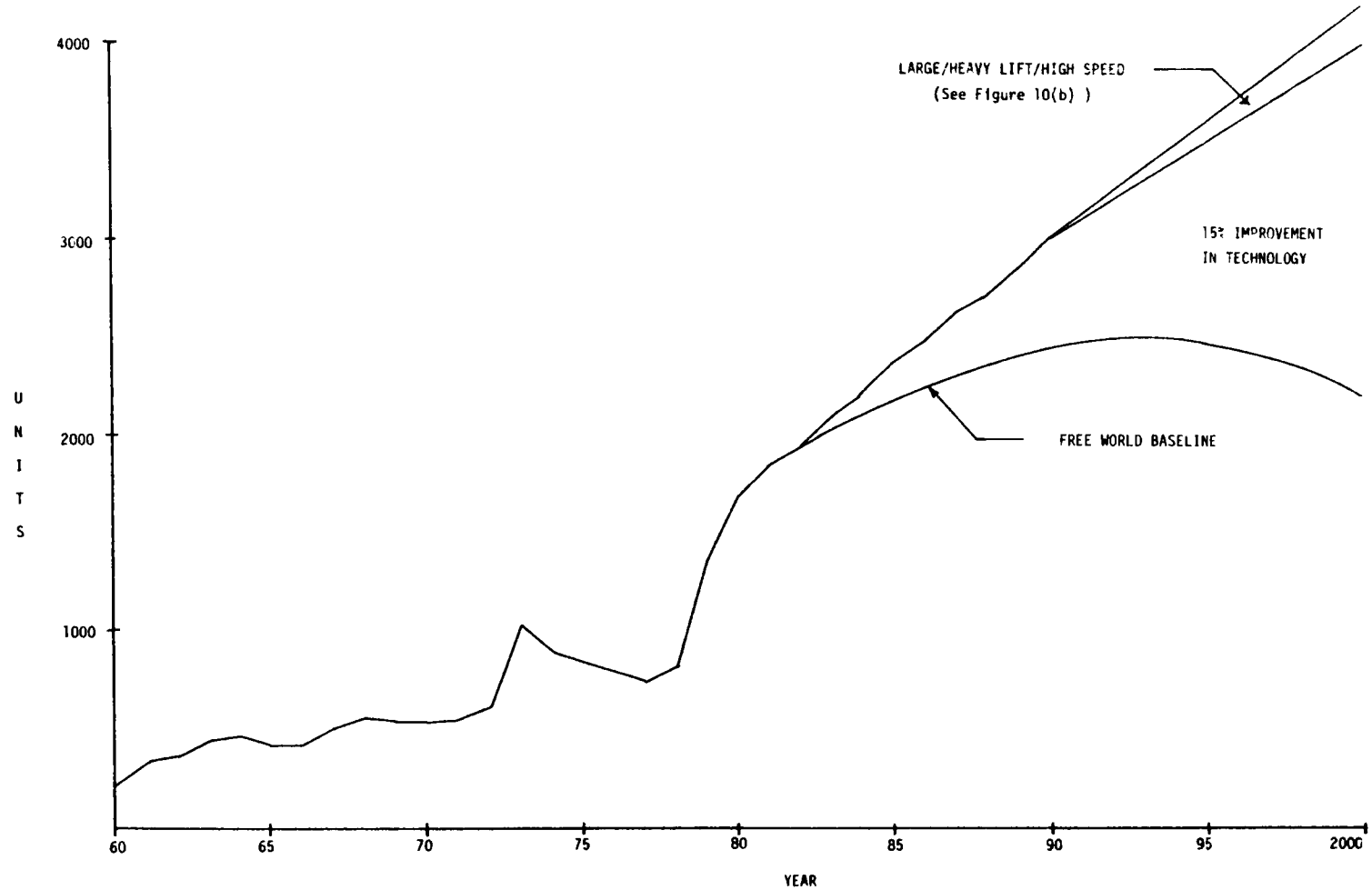

Figure 10(a). - Free world civil rotorcraft market sensitivity to new technology (units).

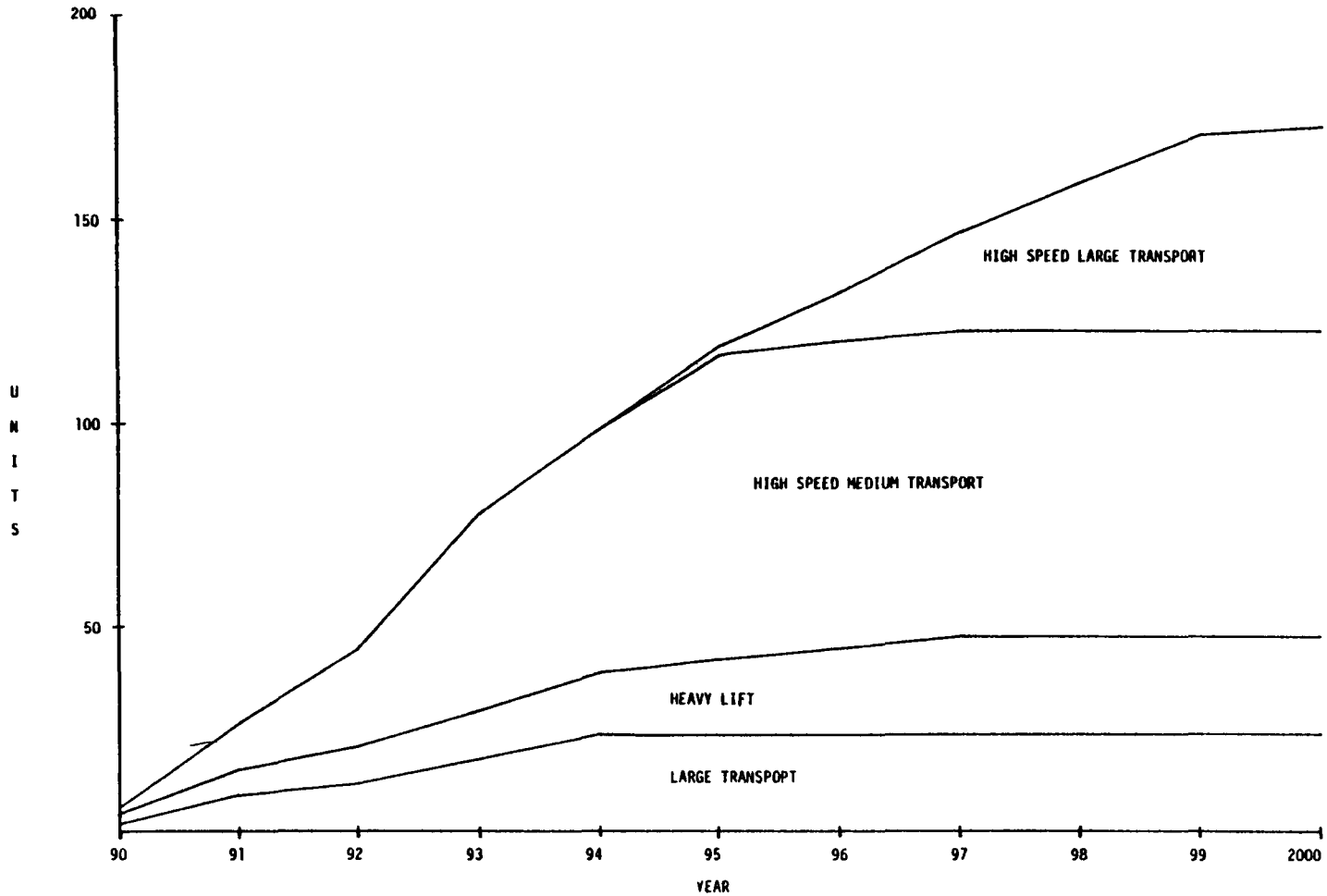

Figure 10(b). - Free world market sensitivity to development of large/heavy lift/high speed rotorcraft (units).

TABLE 10(c). - U.S. & FREE WORLD ROTORCRAFT MARKET SENSITIVITY TO 15% IMPROVEMENT IN TECHNOLOGY (UNITS)

	60	61	62	63	64	65	66	67	68	69	70
U S. BASELINE	188	281	320	382	396	340	377	419	465	434	415
FREE WORLD BASELINE	222	331	370	450	480	423	413	508	569	549	547

	70	71	72	73	74	75	76	77	78	79	80
U S. BASELINE	415	391	490	859	731	704	678	610	652	1040	1264
FREE WORLD BASELINE	547	558	625	1040	914	862	803	757	838	1350	1699

	80	81	82	83	84	85	86	87	88	89	90
U S. BASELINE	1264	1402	1481	1565	1618	1700	1750	1818	1862	1906	1940
U S 15% IMPROVEMENT	--	--	--	9	83	118	158	218	252	326	402
TOTAL U S.	1264	1403	1481	1574	1701	1818	1914	2036	2114	2232	2342
FREE WORLD BASELINE	1699	1851	1952	2030	2105	2180	2245	2305	2355	2402	2442
F W 15% IMPROVEMENT	--	--	--	64	116	189	241	325	370	461	553
TOTAL F W.	1699	1851	1952	2094	2221	2369	2486	2630	2725	2863	2995

	90	91	92	93	94	95	96	97	98	99	2000
U S. BASELINE	1940	1956	1956	1936	1898	1820	1762	1664	1542	1398	1210
U.S. 15% IMPROVEMENT	402	447	542	676	819	1010	1141	1354	1574	1807	2093
TOTAL U S	2342	2403	2498	2612	2717	2830	2903	3018	3116	3205	3303
FREE WORLD BASELINE	2442	2480	2490	2500	2495	2470	2415	2402	2360	2302	2212
F W 15% IMPROVEMENT	553	617	709	801	908	1035	1192	1307	1451	1611	1803
TOTAL F.W.	2995	3097	3199	3301	3403	3505	3607	3709	3811	3913	4015

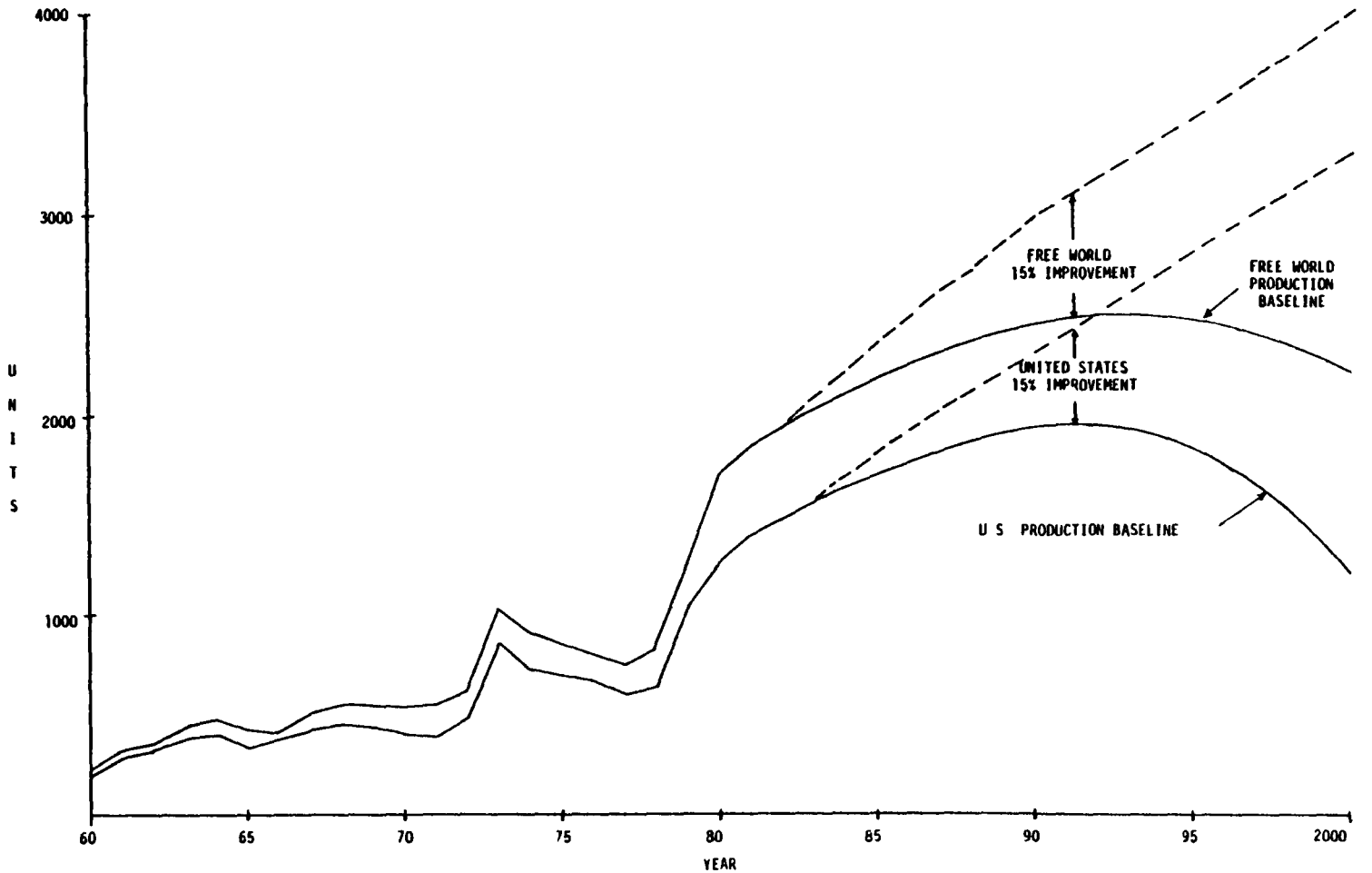

Figure 10(c). - U.S. & free world civil rotorcraft market sensitivity to 15% improvement in technology (units).

TABLE 10(d). - U.S. BASELINE ROTORCRAFT MARKET SHARE OF FREE WORLD TOTAL ROTORCRAFT MARKET WITH ADVANCED TECHNOLOGY (UNITS)

	80	81	82	83	84	85	86	87	88	89	90
U S BASELINE	1264	1402	1481	1565	1618	1700	1750	1818	1862	1906	1940
TOTAL FREE WORLD MARKET	1699	1857	1952	2094	2221	2369	2486	2630	2725	2863	3001

	90	91	92	93	94	95	96	97	98	99	2000
U S BASELINE	1940	1956	1956	1936	1898	1820	1762	1664	1542	1398	1210
TOTAL FREE WORLD MARKET	3001	3124	3244	3379	3502	3624	3739	3856	3970	4084	4188

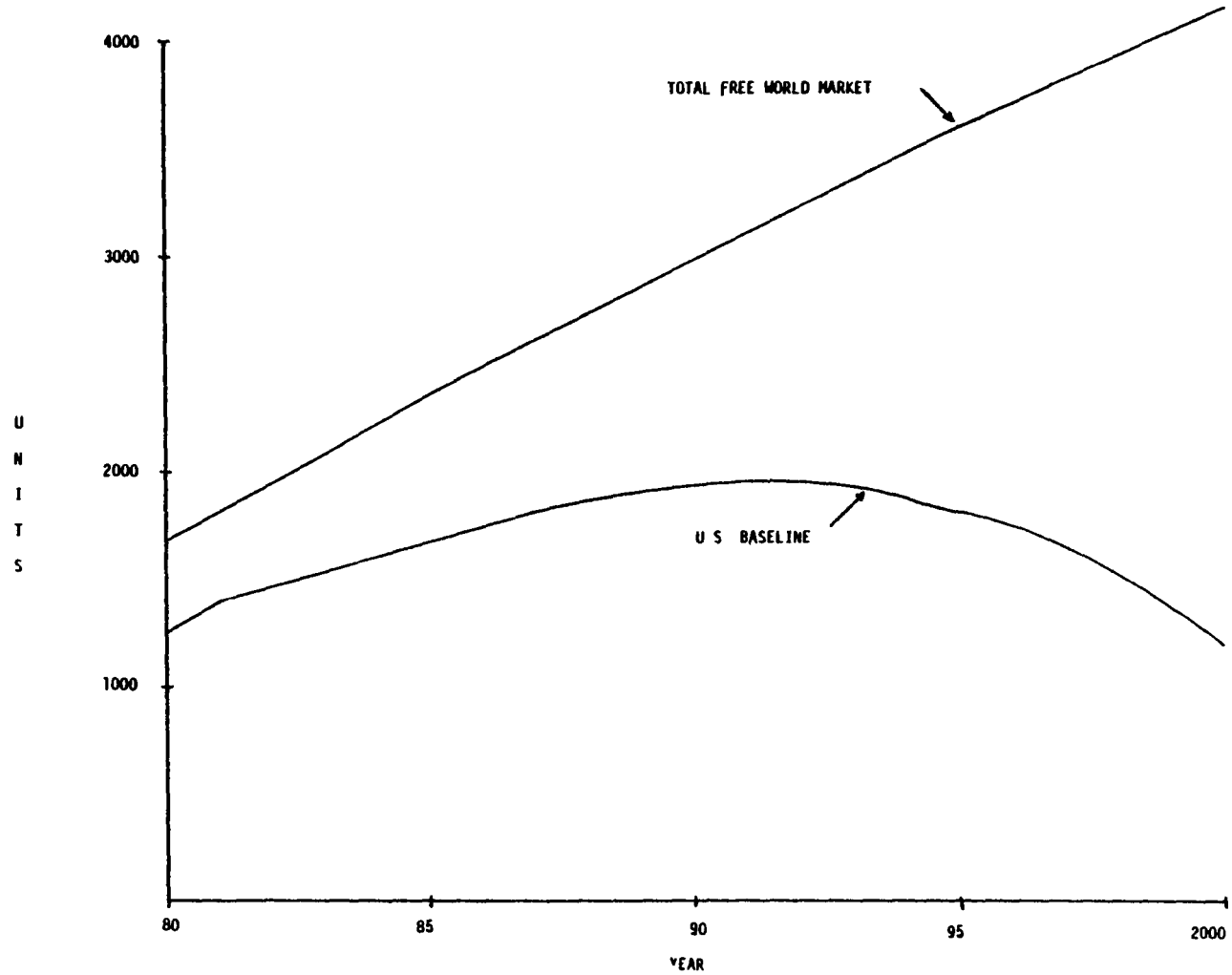

Figure 10(d). - U.S. Baseline rotorcraft market share of free world total rotorcraft market with advanced technology (units).

TABLE 10(e). - FREE WORLD CIVIL ROTORCRAFT MARKET SENSITIVITY TO NEW TECHNOLOGY ($ MILLIONS)

	60	61	62	63	64	65	66	67	68	69	70
BASELINE	15	19	29	36	35	40	36	53	78	92	67

	70	71	72	73	74	75	76	77	78	79	80
BASELINE	67	89	111	200	233	260	239	288	365	550	808

	80	81	82	83	84	85	86	87	88	89	90
BASELINE	808	1078	1320	1510	1699	1906	2110	2398	2690	3034	3375
15% IMPROVEMENT	--	--	--	+ 48	+ 94	+ 165	+ 227	+ 343	+ 422	+ 581	+ 769
TOTAL	808	1078	1320	1558	1793	2071	2337	2741	3112	3615	4144

	90	91	92	93	94	95	96	97	98	99	2000
BASELINE	3375	3720	4033	4375	4716	5039	5337	5716	6065	6399	6636
15% IMPROVEMENT	+769	+926	+1149	+1402	+1716	+2111	+2634	+3111	+3729	+4479	+5409
LARGE TRANSPORT	+180	+875	+1260	+2039	+2938	+3173	+3427	+3698	+3996	+4315	+4660
HEAVY LIFT	+48	+155	+252	+362	+489	+635	+800	+986	+1066	+1150	+1242
HIGH SPEED MEDIUM TRANSPORT	+40	+259	+559	+1210	+1632	+2205	+2378	+2573	+2775	+3000	+3240
HIGH SPEED LARGE TRANSPORT	--	--	--	--	--	+176	+1142	+2467	+3996	+5755	+6475
TOTAL	4412	5935	7253	9388	11491	13339	15718	18551	21627	25098	27662

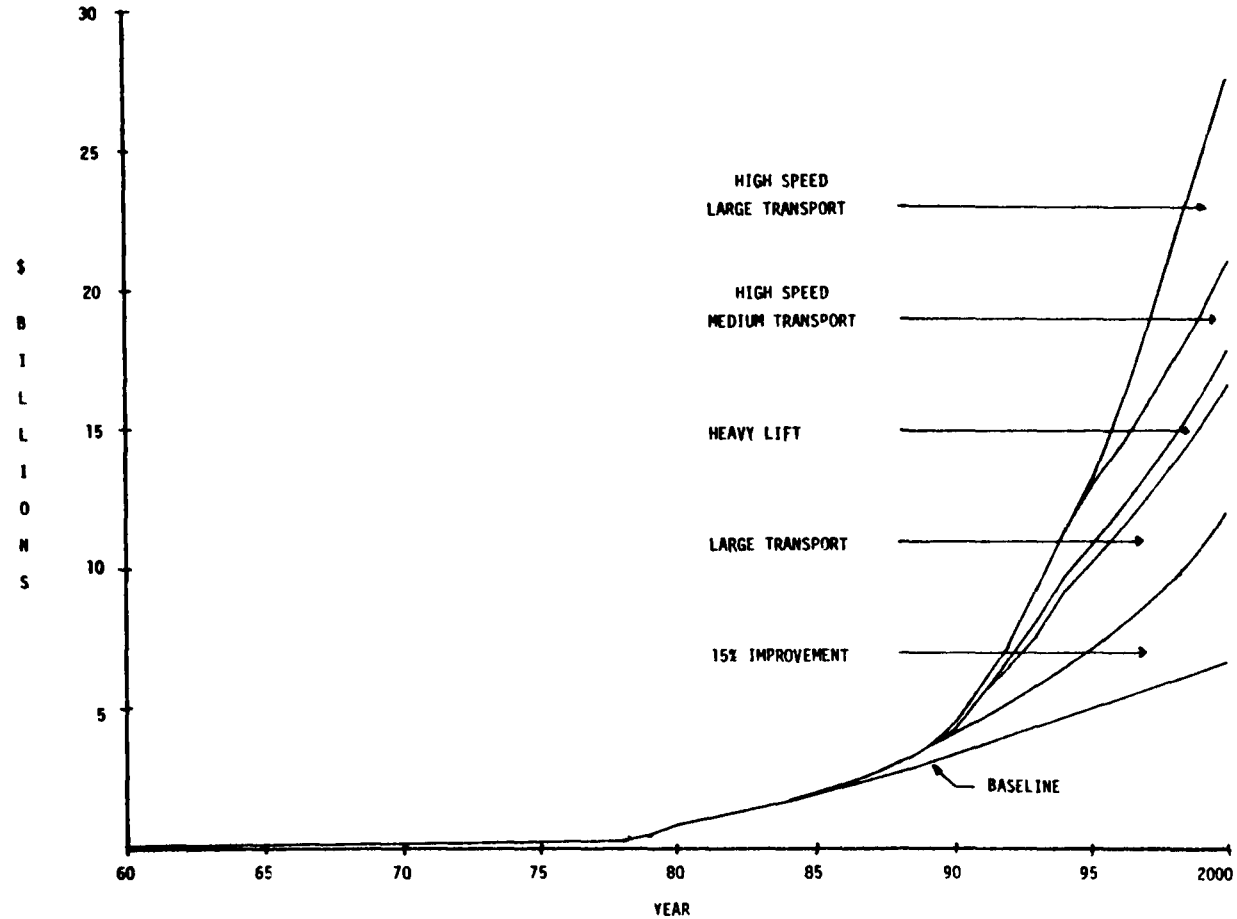

Figure 10(e). - Free world civil rotorcraft market sensitivity to new technology ($ billions).

TABLE 10(f). - U.S. & FREE WORLD ROTORCRAFT MARKET SENSITIVITY TO 15% IMPROVEMENT IN TECHNOLOGY ($ MILLIONS)

	60	61	62	63	64	65	66	67	68	69	70
U S BASELINE	13	16	23	29	26	31	30	41	64	75	48
FREE WOPLD BASELINE	15	19	29	36	35	40	36	53	78	92	67

	70	71	72	73	74	75	76	77	78	79	80
U.S. BASELINE	48	57	83	149	169	201	190	186	216	362	557
FREE WORLD BASELINE	67	89	111	200	233	260	239	288	365	550	808

	80	81	82	83	84	85	86	87	88	89	90
U S. BASELINE	557	755	951	1118	1247	1394	1572	1809	1902	2312	2579
U S 15% I MPROVEMENT	--	--	--	6	52	97	142	218	403	395	535
TOTAL U S	557	755	951	1124	1299	1491	1714	2027	2305	2707	3114
FREE WORLD BASELINE	808	1078	1320	1510	1699	1906	2110	2398	2690	3034	3375
F.W 15% IMPROVEMENT	--	--	--	48	94	165	227	343	422	581	769
TOTAL F W.	808	1078	1320	1558	1793	2071	2337	2741	3104	3615	4144

	90	91	92	93	94	95	96	97	98	99	2000
U.S BASELINE	2579	2809	3033	3243	3433	3556	3719	3792	3684	3717	3474
U S. 15% IMPROVEMENT	535	642	841	1132	1482	1974	2409	3086	3875	4805	6009
TOTAL U.S.	3114	3451	3874	4375	4915	5530	6128	6878	7559	8522	9483
FREE WORLD BASELINE	3375	3720	4033	4375	4716	5039	5337	5716	6065	6399	6636
F.W 15% IMPROVEMENT	769	926	1149	1402	1716	2111	2634	3111	3729	4479	5409
TOTAL F.W.	4144	4646	5182	5777	6432	7150	7971	8827	9794	10878	12045

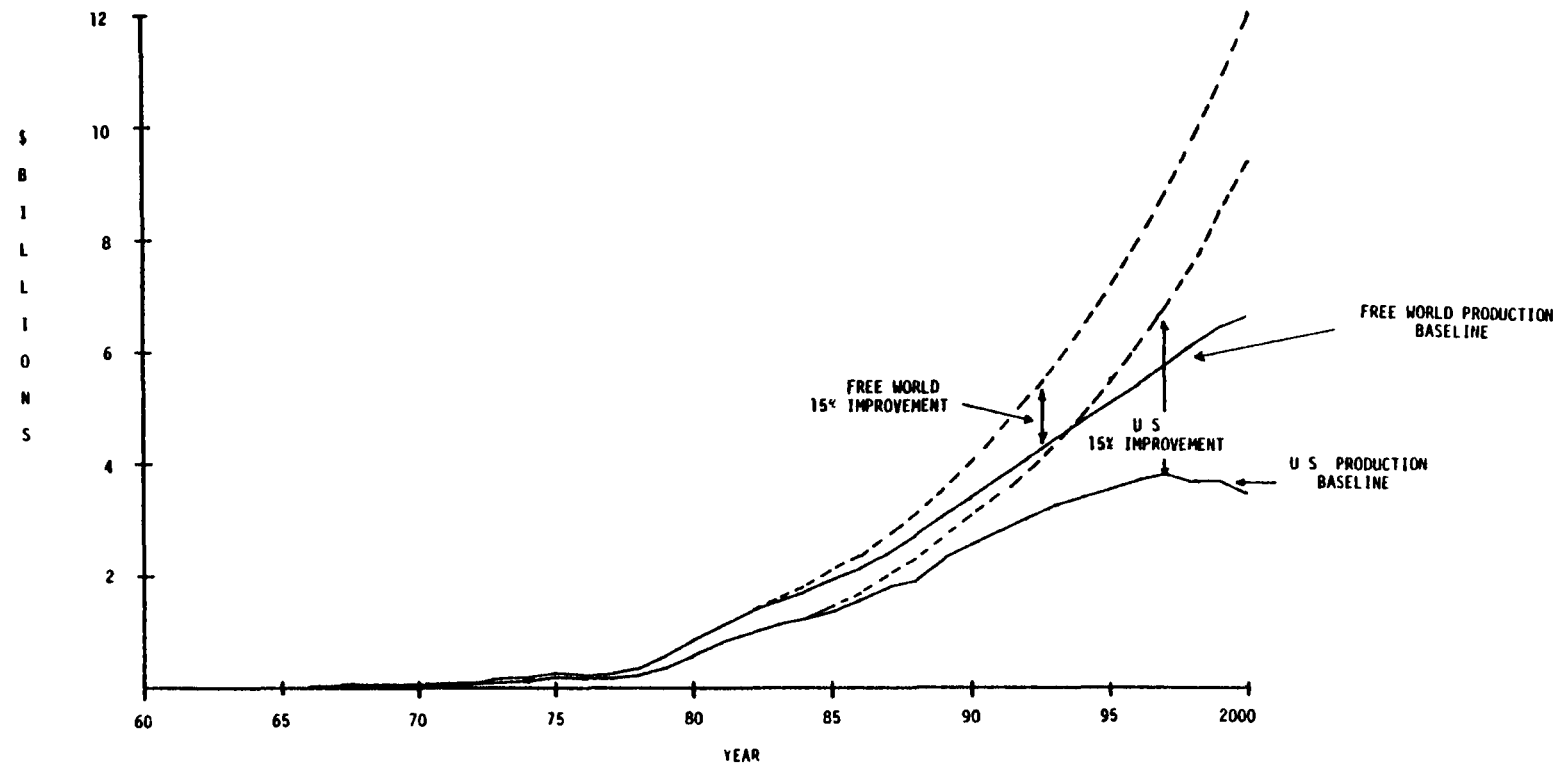

Figure 10(f). - U.S. & free world rotorcraft market sensitivity to 15% improvement in technology ($ billions).

TABLE 10(g). - U.S. BASELINE ROTORCRAFT MARKET SHARE OF FREE WORLD TOTAL ROTORCRAFT MARKET WITH ADVANCED TECHNOLOGY ($ MILLIONS)

	80	81	82	83	84	85	86	87	88	89	90
U S BASELINE	557	755	951	1118	1247	1394	1572	1809	1902	2312	2579
TOTAL FREE WORLD MARKET	808	1078	1320	1558	1793	2071	2337	2741	3112	3615	4412

	90	91	92	93	94	95	96	97	98	99	2000
U S BASELINE	2579	2809	3033	3243	3433	3556	3719	3792	3684	3717	3474
TOTAL FREE WORLD MARKET	4412	5935	7253	9388	11491	13339	15718	18551	21627	25098	27662

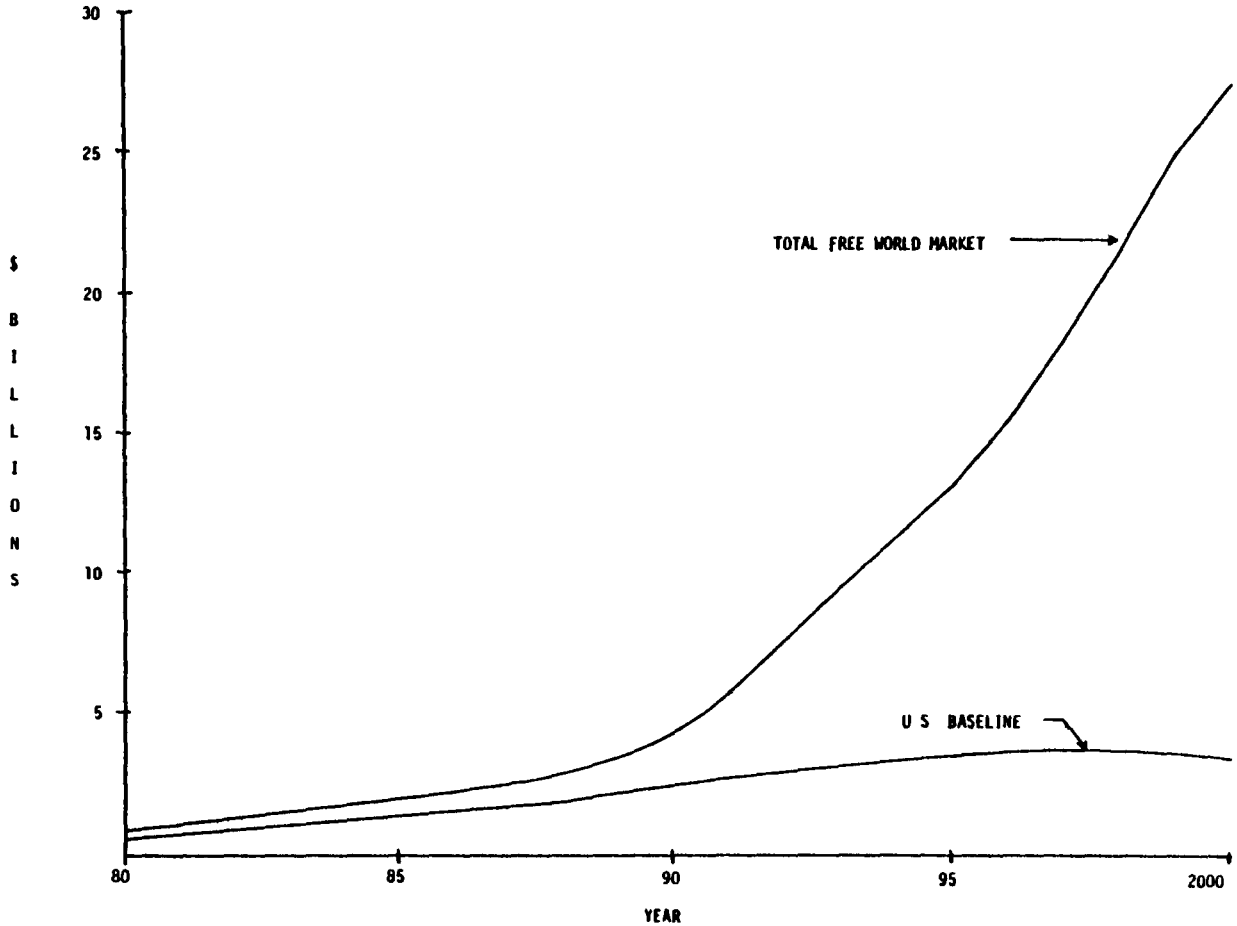

Figure 10(g). - U.S. baseline rotorcraft market share of free world total rotorcraft market with advanced technology ($ billions).

CONCLUSIONS

1. The U.S. is holding its own in the advance of rotorcraft technology; however, a concentrated coordinated effort across the board could provide advances in reduced weights and fuel consumption that would constitute a step forward comparable to the introduction of the gas turbine.

2. Advances in technology offer the best route to rotorcraft penetration of the general aviation market while the development of high speed transport helicopters and development of city center heliports offers the only major opportunity to penetrate the air transport market.

3. The Free World civil rotorcraft market has not yet approached saturation and will continue to double each decade, approaching 3000 units per year by 1990.

4. Many military forces, able to procure rotorcraft in substantial quantities, have achieved their force goals and now procure for attrition replacement and modernization. Production is not expected to exceed 1000 units per year again unless there is another major conflict, such as Vietnam.

5. Advancing technology of materials and systems, increasing size, and inflation, all are combining to advance the cost of helicopters at an ever increasing rate, advancing the average cost of a rotorcraft from approximately $900,000 in 1979 to more than $2.5 million in 1990.

6. Production know-how, an infusion of large doses of new technology, will cause the U.S. to continue to lead free world rotorcraft production despite foreign advances in technology and government subsidy.

7. The high cost of a small production run in less wealthy countries and increasing rotorcraft know-how in wealthier countries will keep licensed production at a relatively low level for the next decade.

8. The U.S. will continue to lead the free world in civil rotorcraft markets, accounting for more than one-half of the units, while holding approximately one-third of the military market.

9. The light single turbine will continue to dominate the civil rotorcraft market in units through the next decade,

accounting for 60 percent of the market, while medium twins and the emerging light twins will account for 65 percent of the dollars.

10. The corporate and private owner market, closely followed by the resource exploration market, will continue to dominate U.S. civil rotorcraft sales, as in the free world. International public service is also a strong market.

11. General aviation dominates the free world civil aircraft market in units while air transport dominates the market in dollars, offering tempting targets for penetration by rotorcraft.

12. Except for the Vietnam era, military rotorcraft production has not gained appreciably on fixed wing production in units and has fallen well behind in dollars.

13. The U.S. will continue to constitute more than 50 percent of the rapidly growing free world civil rotorcraft fleet while decreasing to 40 percent of the more gradually increasing military fleet.

14. The new administration tax policies for U.S. business, if carried out, will aid in offsetting the government subsidies of foreign manufacturers.

15. The U.S. government should move carefully in implementing environmental controls, such as noise standards, less the U.S. industry be stifled in world markets.

16. A major world wide shortage of pilots and mechanics will soon hamper the growth of civil markets unless inroads are made against the high cost of training.

17. The world wide need for energy sources, the acquisition of them, the safeguarding of them, the wealth provided by them, and the poverty incident to their absence, are the over-riding driving forces which control the destiny of rotorcraft.

ENCLOSURE I

MARKET ENVIRONMENT

General

The 1980's will see substantial redirection of the worldwide political, military, economic, technical, and social trends of the 1970's.

Political-Military

The persistent withdrawal of the U.S. from a position of world dominance peaked in the late 1970's and is turning about. However, the center of U.S. interest is refocusing on Middle East energy resources instead of Western Europe, and on China instead of Korea and Japan.

Detente is in dissolution, fine cracks in NATO are beginning to widen, and a major struggle for power is underway in the Middle East, probably to be followed by a similar struggle in S.E. Asia. The U.S. can be expected to begin to "hedge its bets" by rebuilding its relationships with the countries of the Western Hemisphere, offering to trade technology for natural resources.

In Latin America, the USSR can be expected to stimulate internal communist takeovers, particularly in Central America and the Caribbean in countries surrounding the newly found huge oil fields of Mexico.

Economic

Energy, in the form of oil, continues to be the driving force of the world economies for the foreseeable future.

Polarization of wealth due to oil started in the early 1970's. It has intensified dramatically since that time concurrent with the tenfold price increase.

There are 30 countries who are self-sufficient in oil. Eight more countries have the potential of becoming self-sufficient. These countries, for the most part, are destined to generate huge reserves that can be spent on development. This creates a favorable helicopter market to satisfy a complete spectrum of needs and desires. The economies are rapidly growing or will soon begin to grow.

There are approximately seven developed countries, deficient in petroleum, that can be expected to maintain a reasonable

balance of trade (and therefore a reasonably level economy) over the next decade by exporting manufactured goods and technology. They too will have a somewhat favorable market for helicopters.

Five countries, who have an abundance of other minerals (copper/silver/gold/diamonds/etc.) or agricultural products (cocoa/coffee/grain/lumber/etc.), will continue to move in and out of a position of a favorable balance of trade, dependent upon the fluctuations in price of the commodity. Their economies will fluctuate accordingly. During down periods, monetary reserves are usually husbanded for the procurement of petroleum or the expense of the import of capital goods (including helicopters).

The remaining approximately 100 countries of the world, deficient in petroleum or offsetting exports, are destined to suffer an unfavorable balance of trade, inflation, economic stagnation, and eventually can be expected to decline into an agrarian economy.

Technical

The technical environment in which the helicopter industry finds itself today and for the next decade is in a state of consolidation, brought about by two causes.

A large part of industry effort today is devoted to application and proving technology developed over the past two decades in such areas as composite materials, fiber-optics, and microelectronics. The impetus of the U.S. space program, which made major contributions to the recent explosion in technology, has receded somewhat.

Advanced technology is a province of the industrialized free world -- the U.S., Germany, France, the Netherlands, France, Sweden, Italy, Israel, and Japan. All of these are hostage to the accelerating price of petroleum and therefore subject to an inbalance of trade, resultant inflation, and a general deterioration of wealth to spend on advancement of technology. These nations can maintain a level of balance of trade by selling technology to other nations. At some point in time the knowledge will have been transferred and these nations are destined to a more rapid decline unless energy sources are re-established.

Social

The incessant pressure on all nations resulting from population increases, combined with the development of satellite communications, is causing a reshaping of national concepts, particularly in the third world of emerging nations.

The Afghanistan camel driver cannot help developing a surge of "want" when he sees a picture via satellite communications of a Mercedes automobile on television in his village. These kinds of pressures are developing throughout Africa, Latin America, Eastern Europe, and most importantly in China and the USSR.

These pressures inevitably cause governments (including totalitarian) to seek release through social programs of land reform, increased agricultural production, and increased social programs such as medical aid. They also cause increased actions to protect a status quo through police activities and military presence.

All of these actions and reactions create an environment conducive to procurement of helicopters in the public sector of societies.

ENCLOSURE II

MARKET ANALYSIS

The historical helicopter data compiled for this task were drawn from the Bell Helicopter Textron data base. This data base is considered proprietary to Bell. In it, the history of each individual helicopter, insofar as possible, has been traced from its source of manufacture to its current owner. This trace covers location, mission, owner, status, and method of transfer when changing owner or location. This trace, in the form of a series of transactions, for each helicopter, has been entered into the BHT computerized data base.

Seventy-five countries were selected for intensive analysis. This analysis for each country had five major elements which bear upon helicopter procurement.

The geographic analysis included; a determination of the area, of the country in square kilometers, the percent above 1000 meters of altitude, the highest minimum en-route altitude for IFR flight, the length of coastline to be patroled, and the width of the continental shelf which largely determines the limit of economic activity (fishing and petroleum exploration) which most have aerial surveillance for rescue and security purposes.

The climatic analysis included a determination of the minimum and maximum monthly average temperatures, annual rainfall, annual days of rain, and relative humidity. The geographic and climatic analysis largely determines the performance and configuration requirements of a helicopter operating in that environment. (Performance in terms of range and excess power for hot, high operations -- configuration in terms of single engine versus multi-engine for IFR operations).

The political analysis included a determination of the type of government (free or controlled society), its affiliations with other countries, and particularly its relations with the United States. It also included an analysis of the internal threat, leading to requirements for national police or military force requirements.

The military analysis included a determination of helicopter force requirements as to mission and quantity and an assessment of the current and future threat, both internal and external, leading to a projection of future force requirements. The inventories and annual procurement of helicopters were related to the defense budget, the national budget, and the gross domestic product over the past twenty years.

The demographic analysis included the growth in population of the country and a determination of the major population centers, their size and the distance between them, leading to an analysis of civil government requirements (police, fire, ambulance).

The economic analysis included a determination of the gross domestic product and its 20-year trend in real terms, and the proportion divided between the military, civil, government, and the private sector of the economy. The analysis also included a determination of trends in petroleum production versus consumption, overall energy production versus consumption, electric generating capacity, construction index, industrial index, consumer price index, exports versus imports, and national monetary reserves. An analysis was also made of the historical relationship of offshore oil exploration activity to helicopters and the future indicated by current trends, leases for future exploration, and geophysical reports. These data were all used in making a subjective forecast of national gross domestic product.

As noted in the introduction to this report, pricing has been derived in several ways. Commercial helicopter pricing varies widely between manufacturers, dependent upon what equipment is included in the base price and what equipment is added for the mission to be performed. Also, foreign manufacturers do not follow published prices, charging "whatever the traffic will bear." For this study only the new (initial price) has been used.

The basic document used for commercial pricing is the 1980 edition of "The Official Helicopter Blue Book" published by Helicopter Financial Services, Inc. The prices were the average equipped helicopter by model and year. Because of the vagaries of pricing by foreign manufacturers, Blue Book pricing was applied world wide. Where pricing for certain years was not available in the "Blue Book," pricing from a year when pricing was known was adjusted by the change in consumer price index of the country of manufacture.

Military helicopters were priced in two ways. For those of foreign manufacture, Blue Book pricing was used, for the most part, unless other pricing was available. The U.S. government provides U.S. military helicopter manufacturers with government furnished equipment (i.e., engines, avionics, weapons, etc.) for installation. Therefore, the manufacturers price does not reflect the total price. Average mid-production run "fly away" pricing was obtained from agencies of the U.S. Department of Defense. This pricing included government furnished equipment. This price was adjusted by the appropriate U.S. consumer price index to establish annual prices.

This annual pricing was applied to both U.S.-manufactured helicopters and those manufactured in foreign countries under license by U.S. manufacturers. Forecast pricing for both civil and military aircraft was based upon an 8 percent per year inflation rate.

U.S. fixed wing production, inventory, and pricing was taken from published reports of the Federal Aviation Administration, the Aerospace Industries Association, the International Civil Aviation Organization, and the General Aviation Manufacturers Association.

In gathering data for direct employees engaged in manufacture of helicopters, it became evident that personnel accounting methods used in the industry precluded identification of those direct employees engaged in manufacture of end item helicopters as opposed to spare parts manufacture (e.g., rotor blades are made for both new production aircraft and for replacement spares by the same direct employees). The figures shown, therefore, reflect total direct employees as differentiated from overhead and indirect. In order to estimate the employees for companies who declined to provide requested data, the ratio of employees to airframe weight produced was calculated for those companies who did respond, and these calculations were used to compute manpower for nonresponding companies manufacturing similar products. The forecast was computed in the same manner, taking into account improved manufacturing techniques and increased employee productivity.

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15 Supplementary Notes

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16 Abstract

The future military and civil worldwide market potential for current and future rotorcraft configurations was assessed. Comparisons by region, mission, civil or military, etc., are made for both historical and forecast data. A comprehensive historical data base was utilized to determine historical and future trends. Consideration was given to socio-political, economic, and technological factors in determining future trends.

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